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# INVENT: FOREST INVENTORY SYSTEM FOR NEW HAMPSHIRE LANDOWNERS

by

D. S. Linden and J. P. Barrett

NEW HAMPSHIRE  
AGRICULTURAL EXPERIMENT STATION  
UNIVERSITY OF NEW HAMPSHIRE  
DURHAM, NEW HAMPSHIRE

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The program was written in FORTRAN-10 on the DECsystem-10 Model 1090 Computer at the University of New Hampshire. A card deck of the program may be obtained by contacting:

Dr. James P. Barrett  
Institute of Natural and Environmental Resources  
University of New Hampshire  
Durham, New Hampshire 03824

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## ABSTRACT

A computerized forest inventory system has been developed to meet the needs of New Hampshire landowners and foresters. The system will analyse all sampling designs currently in wide use throughout the State producing tables easily understood by landowners. The system includes a rigorous statistical analysis of volume standard errors as well as a newly developed height double sampling technique. The system is available through the Institute of Natural and Environmental Resources.

KEY WORDS: Forest inventory. Computer inventory. Sampling. Double sampling.

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INVENT:

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INTRODUCTION

INVENT is a computerized forest inventory processing system designed for New Hampshire landowners. INVENT was designed with the following five goals in mind:

1. Produce a system that will analyse all sampling designs and methods presently in wide use throughout the State.
2. Produce output tables easily understood by foresters and landowners--output tables that look as if they were designed by a forester, not a computer.
3. Find and implement volume equations that are well adapted to the New Hampshire species--calculate both board-foot and cubic-foot volumes.
4. Indicate the reliability of volume estimates.
5. Produce a system that any forester can use and understand--a system available to all foresters at low cost.

The realization of these goals is the result of two years work in close cooperation with consulting foresters, county foresters, and forest industry. As a result, New Hampshire foresters have "been emancipated from the drudgery and limitations of computation and can concentrate on forest data needs." (Davis 1966, p. 282).

The use of INVENT is made available by the Institute of Natural and Environmental Resources at the University of New Hampshire. Institute personnel will process data from tally sheets submitted by subscribing foresters. Persons interested in using the system should contact Professor James Barrett at I.N.E.R., University of New Hampshire.

This publication is written in four separate sections. Section 1 contains all the information a field forester needs to know to utilize the service. Section 2 describes how the data is computer coded and how the program is run. Section 3 documents the computer program itself with subroutine descriptions

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\*Graduate Research Assistant and Professor of Forest Resources, Institute of Natural and Environmental Resources, respectively.

and variable dictionaries. Section 4 discusses the statistical techniques used within the program. The appendices include tally forms, species code list, volume equations, a guide to sample size determination, a program listing and other supportive material.

SECTION 1. FIELD FORESTER INFORMATION

The first step in a forest inventory is to systematically arrange the forest into groups or categories based upon some definite scheme. We shall refer to these groups as either compartments or strata, using these terms interchangeably. The boundaries of these compartments may be determined by forest type, stocking level, merchantability class or administrative convenience. Whatever the criteria actually used, INVENT will assume that each compartment should be processed individually and will produce a complete set of summary tables for each compartment. Furthermore, INVENT will produce a set of summary tables for all compartments combined assuming stratified random sampling (Cf. Freese 1962). INVENT will handle up to 999 compartments although in practice one would seldom have more than 20 compartments within any forest.

For each forest to be processed, the forester must supply the information requested on the INVENT Processing Request Form (Appendix A, page 48). This information includes:

1. Name and address of forester making request.
2. Number of compartments in the forest.
3. Alternate form class specification.
4. Diameter class size.
5. Confidence level.
6. Tract description.

Alternate Form Class Specification. If heights are measured to the merchantable top, form class equations are used to determine board foot volume. INVENT uses the following form classes as a default:

Hemlock 70                      All other softwoods 76                      All hardwoods 74

Alternate form classes may be specified using the space provided on the INVENT Processing Request Form. These form classes will be used for all compartments in the forest.

Diameter Class Size. INVENT assumes that trees will be grouped into diameter classes. The size of the class is up to the user within the following limitations. The class size must be a whole number. The smallest diameter class allowable is the class size; i.e., if the class size is 2 in. then the first class must be 2 inches. All other diameter classes must be integer multiples of the class size. The maximum diameter class must be less than or equal to 40 inches.

Confidence Level. INVENT uses the 95 percent confidence level as a default. Using this level, there is only a one in twenty chance that the true volume will be outside the confidence interval computed by INVENT (Cf. Freese 1967, p. 11). This is the most common confidence level used in forestry in the Northeast. If the user wishes to use a different level, he may specify that level as long as it is in the range from 65 percent to 99 percent.

Tract Description. A tract description of up to 70 characters should be specified for the forest. This description will be printed at the top of each page of the combined compartment summaries.

For each compartment within the forest, the forester must supply the information requested on the INVENT Compartment Information Form (Appendix A, page 49). This information includes:

1. Compartment name and/or description.
2. Sampling method and sample unit size.
3. Tree height measurement units.
4. Tree top specification.
5. Whether or not the heights of all volume trees were measured.
6. Size of compartment in acres.

Compartment Name. A compartment name and/or description should be specified for each compartment. The description may be up to 70 characters in length and is printed at the top of each page of the compartment output tables.

Sampling Method. INVENT will process point cruises (variable plot), plot cruises (fixed radius plot), strip cruises, and 100 percent tallies. The sampling method need not be the same for each compartment. When using point or plot sampling, a complete statistical analysis of the reliability of the volume estimates will be calculated only if the data for each point or plot is tallied separately. If only summary data is available, no such statistical analysis can be made. When point sampling, the BAF of the angle used must be specified. When plot sampling, the plot size in acres must be specified. Strip cruises are analysed as a plot cruise where only one large plot is sampled. In this case, the plot size is the total acreage of all strips. There is no statistical analysis of reliability on strip cruises. One hundred percent tallies require no statistical analysis of reliability since all trees in the population have been measured. One hundred percent tallies are also treated as a plot cruise where only one large plot is sampled. Here, however, the plot size is equal to the total acreage of the compartment.

Tree Height Measurement. Tree height may be measured in feet or sixteen foot logs to the nearest half-log.

Tree Top Specification. Trees may be measured to a merchantable top or measured by total height. There is also a mixed option where softwoods are measured by total height and hardwoods by merchantable height. As mentioned earlier, form class volume equations for board foot volume are used when merchantable height is specified.

Were Heights of All Volume Trees Measured? INVENT allows double sampling for height (Cf. Freese 1962, p. 43). Using this technique, the forester only measures height on a subsample of the trees. INVENT develops a height-dbh relationship from the height trees sampled and uses this relationship to estimate height for the remaining trees. This method must be used with some caution. On at least one-third of the trees in every species, the height should be measured. At least three height trees must be measured for every species within each compartment. An analysis table of the height-dbh relationship is printed for each compartment using the option. A warning message is

printed if an insufficient number of trees within any species was sampled. (See table 17).

Size of Compartment. The size of each compartment in acres must be specified. If not known exactly it must at least be estimated.

#### Tally Forms and Product Specification

Tally forms are available for use with INVENT (see Appendix A, page 46). Trees are tallied using a two letter species code (Appendix A, page 45), diameter class, height and product. The product column is used as follows: INVENT allows trees to be graded as sawlog or pulpwood. If you do not wish to grade trees simply ignore the product column and all trees will be assumed sawlog. If you do wish to grade trees there are two methods available. You can grade the entire tree as sawlog or pulpwood by entering an S in the product column for sawlog, or entering a P for pulpwood. Alternatively, you may specify the percent sawlog in the tree. If you put 60 in the product column, 60 percent of the volume will go into sawlog and 40 percent will go into pulpwood.

The column marked # is used if two or more trees of the same species, size and product are tallied on a given plot.

#### Output Tables

Seventeen tables are presented as an example of INVENT's output. Tables 1-16 are part of a 59 page inventory report based on a 3 compartment cruise of Whitaker Woods in North Conway, N.H. Tables 1-9 are for compartment 1 while tables 10-16 are for all 3 compartments combined. Table 17 is taken from another cruise where the height double sampling option was used. This table is a summary of that relationship. The output tables are further discussed in section 3 on page 34. However, the tables should be self-explanatory to most foresters.

TABLE 1. JOB CONTROL INFORMATION (INDIVIDUAL STRATUM)

INVENT VER. 3 11/1/78 I.N.E.R. U.N.B.  
 DATE OF RUN: 7-Dec-78  
 B.A.F. = 10.00 NUMBER OF POINTS SAMPLED = 20  
 DIAMETER CLASS SIZE = 2 HEIGHTS MEASURED BY MERCH HEIGHT IN LOGS  
 HEIGHTS OF ALL VOLUME TREES MEASURED STRATUM # 1  
 INPUT FILE NAME: CONWIT.C1 ACREAGE OF TRACT = 47.0  
 CONFIDENCE LEVEL = .95

TABLE 2. SPECIES STAND AND STOCK TABLE

```

*****
*
*                               WHITE PINE                               FC = 76
*
*****
-----
DIAMETER : BASAL AREA : TREES : SAWLOG : SAWLOG : POLPWOOD
CLASS : PER : PER : CUBIC FOOT VOLUME : BOARD FOOT VOLUME : CUBIC FOOT VOLUME
      : ACRE : ACRE : PER ACRE : PER ACRE : PER ACRE
-----
  8 : 1.5 : 4.3 : 0.0 : 0.0 : 30.7
 10 : 1.0 : 1.8 : 16.8 : 82.8 : 0.0
 12 : 4.5 : 5.7 : 91.1 : 535.4 : 0.0
 14 : 5.0 : 4.7 : 109.9 : 705.8 : 0.0
 16 : 7.5 : 5.4 : 168.7 : 1115.0 : 16.4
 18 : 9.0 : 5.1 : 221.1 : 1545.0 : 9.6
 20 : 7.0 : 3.2 : 196.5 : 1405.3 : 0.0
 22 : 3.5 : 1.3 : 101.6 : 747.0 : 0.0
 24 : 2.5 : 0.8 : 70.3 : 538.0 : 0.0
 26 : 4.5 : 1.2 : 134.1 : 1035.6 : 0.0
 28 : 1.0 : 0.2 : 33.7 : 258.3 : 0.0
 30 : 1.0 : 0.2 : 28.4 : 233.1 : 0.0
 32 : 2.0 : 0.4 : 58.4 : 483.9 : 0.0
-----
TOTAL : 50.0 : 34.3 : 1230.6 ± 35% : 8685.2 ± 35% : 56.7 ± 83%
-----

```

MEAN STAND DIAMETER = 16.3 BOARD FOOT COEFFICIENT OF VARIATION = 78%

MERCHANTABLE M.S.D. = 16.3 PULP-WOOD COEFFICIENT OF VARIATION = 183%

PERCENT CROISE = 6.2%







TABLE 7. SPECIES COMPOSITION TABLE

```

.....
*
*
*          SPECIES COMPOSITION BY PERCENT
*
*
.....

```

SPECIES	BASAL AREA	TREES	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
WHITE PINE	45.45	27.59	62.89	67.07	24.50
RED PINE	5.91	5.15	6.90	6.76	0.00
HEMLOCK	20.91	24.67	15.15	12.72	16.75
SUGAR MAPLE	0.91	3.20	0.00	0.00	6.82
RED MAPLE	0.91	1.53	0.26	0.25	3.68
WHITE BIRCH	0.91	2.56	0.25	0.24	3.92
BEECH	5.45	10.80	1.09	0.91	23.03
RED OAK	19.55	24.51	13.46	12.03	21.31
ALL SOFTWOODS	72.27	57.41	84.94	86.56	41.25
ALL HARDWOODS	27.73	42.59	15.06	13.44	58.75

TABLE 8. VOLUME SUMMARY FOR ALL SPECIES

```

.....
*
*
*          VOLUME TOTALS FOR ALL SPECIES
*
*
.....

```

SPECIES	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
WHITE PINE	1230.6	8685.2	56.7
RED PINE	135.0	876.0	0.0
HEMLOCK	296.5	1647.2	38.8
SUGAR MAPLE	0.0	0.0	15.8
RED MAPLE	5.1	32.8	8.5
WHITE BIRCH	4.8	31.4	9.1
BEECH	21.4	118.4	53.3
RED OAK	263.3	1557.9	49.3
ALL SOFTWOODS	1662.2	11208.3	95.4
ALL HARDWOODS	294.7	1740.5	136.0
ALL SPECIES	1956.8	12948.9	231.4

TABLE 9. VOLUME SUMMARY FOR ALL SPECIES EXPANDED BY ACREAGE

```

*****
*
*                               VOLUME TOTALS EXPANDED BY ACREAGE
*
*****

```

SPECIES	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
WHITE PINE	57838	408202	2664
RED PINE	6347	41170	0
HEMLOCK	13936	77419	1822
SUGAR MAPLE	0	0	742
RED MAPLE	240	1542	400
WHITE BIRCH	228	1478	426
BEECH	1004	5563	2505
RED OAK	12377	73222	2317
ALL SOFTWOODS	78122	526792	4486
ALL HARDWOODS	13849	81805	6390
ALL SPECIES	91971	608597	10876

TABLE 10. JOB CONTROL INFORMATION (STRATIFIED TOTAL)

INVENT VER. 3 11/1/78 I.N.E.R. O.N.B.

DATE OF RUN: 7-Dec-78

DIAMETER CLASS SIZE = 2

NUMBER OF STRATA SAMPLED = 3

TOTAL ACREAGE SAMPLED = 105.0

TOTAL POINTS SAMPLED = 56

CONFIDENCE LEVEL = .95

TABLE 11. SPECIES VOLUME TABLE (STRATIFIED TOTAL)

```

.....
*
*                               WHITE PINE                               *
*                               FC = 76  *
*
.....

```

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	914
8	823	2718	1716
10	1499	7465	0
12	5111	30058	0
14	5550	35604	0
16	9600	63484	769
18	14541	100826	453
20	14468	103635	0
22	10177	75100	0
24	7902	60263	0
26	9247	71309	0
28	2506	19544	0
30	2074	16148	0
32	4228	34874	0
34	568	4555	0
36	455	3920	0
TOTAL	88750 ± 26%	629503 ± 26%	3853 ± 73%

TABLE 12. SPECIES VOLUME TABLE (STRATIFIED TOTAL)

```

.....
*
*                               RED OAK                               *
*                               FC = 74  *
*
.....

```

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	1635
8	288	1234	2981
10	4574	23270	622
12	7579	42632	310
14	2901	16995	0
16	4710	29345	0
18	3005	19598	664
20	1403	9308	294
22	218	1674	0
24	0	0	291
28	290	2035	0
TOTAL	24968 ± 37%	146091 ± 36%	6799 ± 61%

TABLE 13. SOFTWOOD SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

ALL SCPTWOODS			
DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	1874
8	1053	3451	4161
10	6105	28274	320
12	10944	61345	107
14	12957	79177	0
16	22644	141792	769
18	26139	172099	591
20	18292	127282	0
22	13103	95876	0
24	9151	68560	0
26	10723	81395	0
28	2799	21620	0
30	3291	24339	0
32	4407	36297	0
34	915	7039	0
36	455	3920	0
40	459	3204	0
TOTAL	143437 ± 19%	955670 ± 19%	7822 ± 50%

TABLE 14. HARDWOOD SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

ALL HARDWOODS			
DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	366	607	7887
8	288	1234	11231
10	9417	48605	2785
12	10012	56781	2805
14	4167	24463	826
16	5472	34023	488
18	3005	19598	1212
20	1403	9308	458
22	381	2825	610
24	0	0	607
26	315	2009	237
28	290	2035	0
TOTAL	35115 ± 26%	201490 ± 26%	29146 ± 27%

TABLE 15. ALL SPECIES SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

*****			
* ALL SPECIES *			
*****			
DIAMETER CLASS :	SAWLOG CUBIC FOOT VOLUME :	SAWLOG BOARD FOOT VOLUME :	PULPWOOD CUBIC FOOT VOLUME :
6 :	366 :	607 :	9760
8 :	1341 :	4685 :	15393
10 :	15522 :	76879 :	3104
12 :	20955 :	118127 :	2912
14 :	17124 :	103641 :	826
16 :	28116 :	175815 :	1257
18 :	29144 :	191697 :	1803
20 :	19695 :	136589 :	458
22 :	13884 :	98701 :	610
24 :	9151 :	68560 :	607
26 :	11038 :	83404 :	237
28 :	3089 :	23655 :	0
30 :	3291 :	24339 :	0
32 :	4407 :	36297 :	0
34 :	915 :	7039 :	0
36 :	455 :	3920 :	0
40 :	459 :	3204 :	0
-----			
TOTAL :	178552 ± 14% :	1157160 ± 14% :	36968 ± 22%
-----			

TABLE 16. VOLUME SUMMARY FOR ALL SPECIES (STRATIFIED TOTAL)

*****			
* VOLUME TOTALS FOR ALL SPECIES *			
*****			
SPECIES :	SAWLOG CUBIC FOOT VOLUME :	SAWLOG BOARD FOOT VOLUME :	PULPWOOD CUBIC FOOT VOLUME :
WHITE PINE :	88750 :	629503 :	3853
RED PINE :	10094 :	65651 :	0
HEMLOCK :	44593 :	260516 :	3746
RD-BL-WB SPRUCE :	0 :	0 :	224
SUGAR MAPLE :	0 :	0 :	742
RED MAPLE :	1072 :	6271 :	6150
WHITE BIRCH :	4474 :	25213 :	3255
YELLOW BIRCH :	89 :	649 :	0
BEECH :	4513 :	23266 :	12200
RED OAK :	24968 :	146091 :	6799
-----			
ALL SOFTWOODS :	143437 :	955670 :	7822
ALL HARDWOODS :	35115 :	201490 :	29146
-----			
ALL SPECIES :	178552 :	1157160 :	36968
-----			

TABLE 17. REGRESSION SUMMARY (IF OPTION USED)

```

*****
*
*           ANALYSIS OF THE HEIGHT - DBH RELATIONSHIP
*
*           MODEL:  HEIGHT = B0 + B1/DBH
*
*****

```

SPECIES	B0 INTERCEPT	B1 SLOPE	R SQUARED	STANDARD ERROR %	AVERAGE HEIGHT	VOLUME TREES	HEIGHT TREES
WHITE PINE	3.296	-21.321	54.0	5.1	1.5	92	40
HEMLOCK	1.799	-8.528	16.2	9.6	1.1	48	23
RED MAPLE	3.106	-29.436	62.1	13.5	0.9	39	11
BLACK CHERRY		*** WARNING ***		0.0	0.0	3	0
SWEET BIRCH		*** WARNING ***		0.0	0.0	1	0
BASSWOOD				0.0	2.0	2	2
RED OAK	1.140	-5.471	30.1	19.7	0.8	5	4
WHITE OAK		*** WARNING ***		0.0	0.0	3	0
BLACK OAK		*** WARNING ***		0.0	0.0	2	0
ELM	1.157	-4.992	18.7	15.0	0.8	9	6
HICKOXY	2.865	-23.076	73.0	9.2	1.3	6	3
ALL SOFTWOODS				4.6	1.4	140	63
ALL HARDWOODS				8.1	1.0	70	26
ALL SPECIES				4.1	1.3	210	89

\*\*\* WARNING \*\*\* INSUFFICIENT NUMBER OF HEIGHT TREES MEASURED FOR THIS SPECIES!





SECTION 2. DATA CODING AND PROGRAM EXECUTION

Program Operating Environment

INVENT was developed on the DEC-10 system at the University of New Hampshire. INVENT is an interactive system acquiring all of its job control related information from the user through a dialogue. Unit 5 (TTY on DEC-10) is used as the input and output device for all of INVENT's interactive dialogue.

For each stratum the plot and tree data must reside on a disk file with a unique name. The name of the file is specified by the user at execution time as INVENT processes each stratum. Unit 21 is used to input each disk file. The file uses a fixed format as described below.

If the user wishes to use alternate form classes, these must reside on a disk file also. The user specifies the name of this file at execution time and unit 1 is used to input this file. The file uses a fixed format as described on page 18.

All output is written to unit 3 (LPT on DEC-10) to a file named INVENT.LPT.

Data File Format and Coding

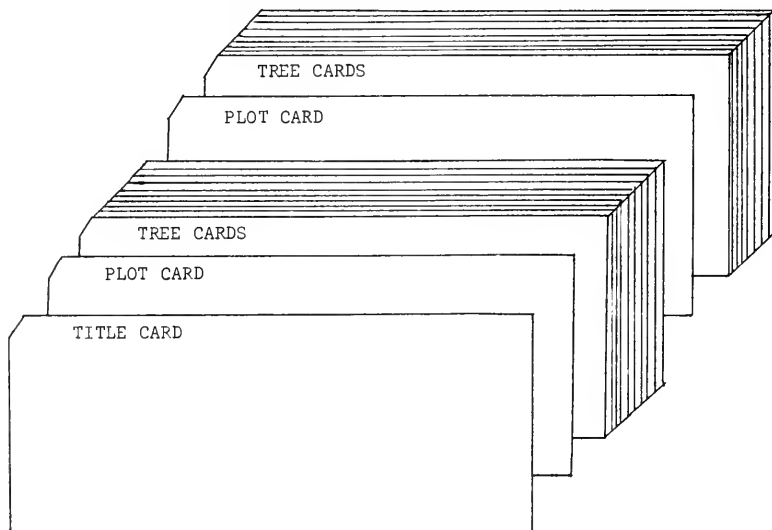
An individual data file must exist for each stratum. The file consists of card images coded as follows:

Card Type	Columns	Format	Variable	Description
Title	1-70	12A5	TITLE	Stratum title
Plot	1-2	I2	POINT	Plot number (1)
	3-5	I3	TREES	Number of trees on plot (1)
Tree	1-2	A2	SPEC	Species code
	4-5	I2	DBH	Diameter at breast height
	6	A1	PROD	Product code (2)
	7-9	F3.0	HEIGHT	Tree height
	10-11	I2	IREP	Number of trees of this description (3)
	12-14	F3.2	PCTSAW	Percent sawlog (4)

- (1) When using the summary option where trees are not tallied by individual plots, only one plot card is used and it is coded as follows: POINT = -9, TREES = number of plots sampled.
- (2) Product codes: Sawlog (S or blank); Pulpwood (P); Percent Sawlog (%).
- (3) If IREP is coded as 0 or blank, the program assumes IREP = 1.
- (4) PCTSAW is ignored unless PROD = %. PCTSAW is coded as a percent (0-100) and the F3.2 format reads it as a decimal (0-1.00).

Examples of various tree card codings may be found in Appendix A, page 44. The species code list is found in Appendix A, page 45.

The data file is constructed by combining the title, plot, and tree cards as follows. The first card in the file is the title card. This is followed by the plot card for plot number 1. The plot card is then followed by all the tree cards for that plot. Next, the plot card for plot number 2 is included followed by its tree cards; and so on for the remaining plots. The actual value of POINT (plot number) need not be consecutive.



An example of an INVENT tally sheet and the resulting data file listing may be found in Appendix A, pages 46 and 47.

#### Alternate Form Class File Coding

The user has the option to specify a set of alternate form classes. Form class only affects volume when tree heights are measured to a merchantable top (see page 3). A file containing these alternate form classes must reside on a disk file. This file consists of four rows and eight columns organized as follows:

Row 1:	Form classes for species	1-8	(see species list in		
Row 2:	"	"	"	9-16	Appendix A, page 45)
Row 3:	"	"	"	17-24	
Row 4:	"	"	"	25-32	

Each row is formatted 8(I2,X).

As an example, assume the following form classes were desired:

All pines	80
Hemlock, Spruces, Ash, Black Cherry	78
Balsam Fir, Tamarack, Cedar Other Softwoods, Sugar Maple White Birch, Yellow Birch	76
All other species	75

The data file that would implement these form classes is:

```
80 80 80 78 76 76 78 78
80 76 76 76 75 78 75 75
75 78 76 76 75 75 75 75
75 75 75 75 75 75 75 75
```

#### Running the Program

Running INVENT consists of interactively supplying the program all job control information. This information includes: alternate form class specification (if desired), diameter class size, number of strata, confidence level, input file name for each strata, sampling method (point or plot), basal area factor or plot size, method of height measurement, acreage of each stratum, and title of combined strata output (if more than one stratum sampled).

This interactive portion of the program is self-explanatory. The program asks the user certain questions while listing the possible answers. The number of questions asked depends on the options used and the number of strata sampled. The questions are asked as each data file is read and processed. Under conditions of heavy computer usage there may be a time lapse of as much as two minutes between certain questions. This process is best explained by example.

Tables 1-16 are part of a 59 page inventory report based on a 3 compartment cruise of Whitaker Woods in North Conway, N.H. Listed below is the entire user-program dialogue that produced that output. Each of the questions asked has been numbered for reference and user responses are underlined. Most questions are totally self-explanatory and therefore only a few will be discussed.

.RUN\_INVENT

1. DO YOU WANT TO READ IN ALTERNATE FORM CLASSES FROM DISK?  
NO
2. ENTER DIAMETER CLASS SIZE  
2
3. ENTER NUMBER OF STRATA  
3
4. INVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.  
DO YOU WISH TO USE A DIFFERENT LEVEL?  
NO
5. ENTER INPUT FILE NAME FOR STRATUM # 1  
CONWIT.C1  
  
WHITAKER WOODS 1978 COMP. 1
6. SPECIFY SAMPLING METHOD  
TYPE POINT OR PLOT  
POINT
7. ENTER B.A.F.  
10
8. ARE HEIGHTS IN FEET OR SIXTEEN FT. LOGS?  
TYPE FEET OR LOGS  
LOGS
9. ARE HEIGHTS TOTAL OR MERCHANTABLE?  
TYPE TOTAL, MERCH, OR MIXED  
MERCH
10. WERE THE HEIGHTS OF ALL VOLUME TREES MEASURED?  
YES
11. ENTER ACREAGE OF TRACT.  
42
12. ENTER INPUT FILE NAME FOR STRATUM # 2  
CONWIT.C2  
  
WHITAKER WOODS 1978 COMP. 2

13. SPECIFY SAMPLING METHOD  
TYPE POINT OR PLOT OR SAME  
SAME
14. ENTER ACREAGE OF TRACT,  
42
15. ENTER INPUT FILE NAME FOR STRATUM # 3  
CONWIT.C3  
  
WHITAKER WOODS 1978 COMP. 3
16. SPECIFY SAMPLING METHOD  
TYPE POINT OR PLOT OR SAME  
SAME
17. ENTER ACREAGE OF TRACT,  
16
18. WHAT DO YOU WANT TO TITLE THE COMBINED STRATA OUTPUT?  
WHITAKER WOODS 1978 STRATIFIED TOTAL COMPS. 1 - 3  
  
END OF EXECUTION  
CPU TIME: 4.32 ELAPSED TIME: 5:31.23  
EXIT

Answering NO to questions 1 and 4 indicates the user will use the default form classes and the default confidence level of 95 percent.

Question 9 asks the user if heights are total or merchantable and offers three responses: TOTAL, MERCH, or MIXED. The response MIXED would have indicated that softwoods were measured by total height while hardwoods were measured by merchantable height. In this case, however, MERCH was answered indicating merchantable height was used on all trees.

There would be a pause of about thirty seconds between questions 11 and 12 as the program processes stratum 1.

Question 13 asks the user to specify the sampling method as did question 6. However, question 13 offers an additional response: SAME. Answering SAME indicates that in stratum 2 the sampling method, basal area factor, and method of height measurement are identical to those in the previous stratum. Therefore questions 7-10 are not repeated.

Once again there would be a pause of about thirty seconds between questions 14 and 15 and between questions 16 and 17.

Question 18 asks for a title for the combined strata output. This title may be up to 70 characters in length and is printed at the top of each table in the combined strata output section.

After an additional pause of about thirty seconds the end of execution message appears and the output is sent to the line printer queue.

The following example is included to illustrate the alternate form class option and the alternate confidence level option.

.RUN INVENT

1. DO YOU WANT TO READ IN ALTERNATE FORM CLASSES FROM DISK?  
YES

1A. ENTER FORM CLASS FILE NAME  
WHIT.FRM

1B. DO YOU WANT A LIST OF THE FORM CLASSES JUST READ?  
YES

WF = 80	RF = 80	PF = 80	HM = 78
BF = 76	TA = 76	SP = 78	NS = 78
SC = 80	CE = 76	OS = 76	SM = 76
RM = 75	WA = 78	WI = 75	AS = 75
YP = 75	BC = 78	WB = 76	YB = 76
SB = 75	GB = 75	BE = 75	BW = 75
RO = 75	WO = 75	BO = 75	EL = 75
GU = 75	HI = 75	HH = 75	OH = 75

2. ENTER DIAMETER CLASS SIZE  
2

3. ENTER NUMBER OF STRATA  
3

4. INVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.  
DO YOU WISH TO USE A DIFFERENT LEVEL?  
YES

4A. ENTER CONFIDENCE LEVEL AS A DECIMAL IN THE RANGE .65 TO .99  
.90

Answering YES to question 1 invokes the alternate form class option. Question 1a asks for the file name while question 1b gives the user the option to list the new form classes. These form classes are the ones described on page 19. Answering YES to question 4 allows the user to specify an alternate confidence level.





SECTION 3. PROGRAM DOCUMENTATION

The FORTRAN program consists of the main program: INVENT; nine sub-programs: FRMCLS, LINREG, GUTS, VOLMER, VOLTOT, STRAT, OUTP1, MDSTI, and MDNRIS; and five named common storage areas: COMUNE, FORMCL, REG, OUT1, and STOUT. A description of each along with a variable dictionary are presented below. The program listings are found in Appendix E.

Common Area COMUNE

COMUNE transfers job control information from the main program to the subroutines.

<u>Variable</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
ACRES	Real	-	Acreage of compartment
BAF	Real	-	Prism factor or plot size
CLASIZ	Int	-	Diameter class size
FRAME	Real(C*5) <sup>1</sup>	-	Sampling method
IFILE	D.P.(C*10)	-	Input file name
LOGANS	Int (C*4)	-	Height measurement length technique
MULT	Int	-	Conversion factor to transform logs to feet
PROBLV	Real	-	Two-tailed area under t-curve
REGANS	Int (C*3)	-	Regression option indicator
SAMMTD	D.P.(C*8)	-	Output title indicating sampling method used
TITLE	Int (C*5)	14	Compartment title
TOPANS	Int (C*5)	-	Height measurement top technique

Common Area FORMCL

FORMCL transfers the form class array.

<u>Variable</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
FC	Int	32	Form class array

Common Area REG

REG transfers information to and from the regression subroutine.

<u>Variable</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
MEANY	Real	35	Average height
MINDBH	Int	32	Minimum diameter sampled for height
NTR	Int	35	Number of height trees sampled
REGCOF	Real	33	Regression slope
REGINT	Real	33	Regression intercept
RSQR	Real	33	Coefficient of determination
SEREG	Real	35	Standard error of the regression
SPECIE	Int (C*2)	32	Species code
TOTNTR	Int	35	Number of non-cull trees above minimum d.b.h. sampled

<sup>1</sup>(C\*5) indicates the variable is used to store 5 characters.

Common Area OUT1

OUT1 transfers processed data to the output subroutine.

<u>Variable</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
BASPAC	Real	40,35	Basal area/acre by d.b.h.
BASTOT	Real	35	Basal area/acre
BDTOT	Real	35	Sawlog bd.ft. volume
BDVLSM	Real	40,35	Sawlog bd.ft. volume by d.b.h.
CBTOT	Real	35	Sawlog cub.ft. volume
CBVLSM	Real	40,35	Sawlog cub.ft. volume by d.b.h.
FINPOP	Real	--	Finite population correction
NPNTS	Int	--	Number of sample units sampled
PLTOT	Real	35	Pulpwood cub.ft. volume
PLVLSM	Real	35	Pulpwood cub.ft. volume by d.b.h.
SEBRD	Real	35	Sawlog bd.ft. volume standard error
SECUB	Real	35	Sawlog cub. ft. volume standard error
SEPUL	Real	35	Pulpwood cub.ft. volume standard error
TREPAC	Real	40,35	Trees/acre by d.b.h.
TRETOT	Real	35	Trees/acre
VARBRD	Real	35	Sawlog bd.ft. volume variance
VARPUL	Real	35	Pulpwood cub.ft. volume variance

Note: All volumes are per acre

Common Area STOUT

STOUT transfers combined strata information to the output subroutine.

<u>Variable</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
BDTST	Real	35	Sawlog bd.ft. volume
BDVLST	Real	40,35	Sawlog bd.ft. volume by d.b.h.
CBTST	Real	35	Sawlog cub.ft. volume
CBVLST	Real	40,35	Sawlog cub.ft. volume by d.b.h.
EFDFBD	Real	35	Sawlog bd.ft. volume effective d.f.
EFDFCB	Real	35	Sawlog cub.ft. volume effective d.f.
EFDFPL	Real	35	Pulpwood cub.ft. volume effective d.f.
PLTST	Real	35	Pulpwood cub.ft. volume
PLVLST	Real	40,35	Pulpwood cub.ft. volume by d.b.h.
STSEBD	Real	35	Sawlog bd.ft. volume standard error
STSECB	Real	35	Sawlog cub.ft. volume standard error
STSEPL	Real	35	Pulpwood cub.ft. volume standard error
TACRES	Real	--	Total acres sampled

Note: All volumes are total

Main Program INVENT

INVENT provides interactive user communication and subroutine control.

Input and output are to unit 5 which is the user's TTY on the DEC-10. The following job control information is acquired interactively from the user:

- (1) Alternate form class specification.
- (2) Diameter class size.
- (3) Number of strata.

- (4) Confidence level.
- (5) Input file name.
- (6) Sampling method and sampling frame.
- (7) Method of height measurement.
- (8) Acreage of strata.
- (9) Title of combined strata output (if more than one strata).

INVENT opens the output file on unit 3 (LPT on DEC-10) naming it INVENT.LPT. INVENT also sets the default confidence level to 95 percent.

The following subroutine calls are made in INVENT: FRMCLS, LINREG, GUTS, OUTP1, OUTP2, STRAT, and STRAT2.

Common Area Used: COMUNE,

Other			
<u>Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
ALPHA	Real	--	Confidence level as a decimal
ALPHCH	Real(C*3)	--	Confidence level change flag
FRMANS	Real(C*3)	--	Form class change flag
III	Int	--	Loop counter for strata number
ISTRAT	Int	--	Number of strata
REPEAT	D.P.(C*8)	--	User message
SVFRAM	Real(C*5)	--	Saves the contents of FRAME

#### Subroutine FRMCLS

FRMCLS is called by INVENT if the user specifies that he wishes to use alternate form classes. FRMCLS interactively asks the user to specify the name of the file where the alternate form classes are stored. This file is read from unit 1 (disk on DEC-10). As in INVENT, unit 5 is used to communicate with the user. The user is given the option to list the new form classes after they are read from the file.

Common Areas Used: FORMCL and REG.

Other			
<u>Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
FCFILE	D.P.(C*10)	--	Input file name
I	Int	--	Implied do loop index
LSTANS	Int	--	Form class list option flag

#### Subroutine LINREG

LINREG is called by INVENT if the user specifies that only the heights of a subsample of the volume trees were measured. LINREG then reads through

the data file specified by the variable IFILE and located on unit 21 (disk on DEC-10). For every species with three or more height trees measured, LINREG fits the following regression model:  $HEIGHT = B_0 + B_1 * 1/DBH$ . The following statistics are calculated and stored in common area REG:

- (1) Regression intercept.
- (2) Regression slope.
- (3) Standard error of the regression.
- (4) Number of height trees measured.
- (5) Total number of merchantable trees sampled.
- (6) Average height.
- (7) Coefficient of determination ( $R^2$ ).
- (8) Minimum diameter of all height trees sampled if less than 8 inches.

LINREG ignores cull trees (HEIGHT = 999). It also checks that input parameters are within the following ranges:

$$1 \leq DBH \leq 40 \quad 0 \leq HEIGHT \leq 7 \text{ if height measured by logs.}$$
$$0 \leq HEIGHT \leq 200 \text{ if height measured in feet.}$$

If data is found outside these ranges, the value is set to the minimum or maximum of the range. If an illegal species code appears, the tree is ignored and an error message is written to unit 5.

LINREG also calculates certain statistics for the Softwood, Hardwood and All Species accumulations. These statistics include (3), (4), (5) and (6) above.

Common Area Used: REG.

Other

<u>Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
CORMNY	Real	--	Corrected mean height for species
CORNTR	Real	--	Corrected number of trees sampled
COVXY	Real	33	Covariance of X and Y
DBH	Int	--	Diameter at breast height
HEIGHT	Real	--	Tree height
IDUMMY	Int	--	DO loop index for reps on input
IREF	Int	--	Number of reps on input
ISPEC	Int	--	Species loop counter
ITYPE	Int	--	Forest type code
JTYPE	Int	--	Forest type code
LOOP	Int	--	Loop counter
MEANX	Real	35	Mean of X
MEANY	Real	35	Mean of Y
MNYCOR	Real	3	Corrected mean height for forest types

<u>Other Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
MSE	Real	--	Mean square error
NTRCOR	Int	3	Corrected number of trees for forest type
NUMREG	Int	3	Number of regressions run
POINT	Int	--	Point number
SPEC	Int(C*2)	--	Species input code
SSE	Real	--	Sum of the squares of error
TREES	Int	--	Number of trees on a sample unit
TYP SSE	Real	3	Forest type error sum of squares
VARX	Real	33	Variance of X
VARY	Real	33	Variance of Y
X	Real	33	1/D.B.H.
XSUM	Real	33	Sum of X
XSUMSQ	Real	33	Sum of X <sup>2</sup>
Y	Real	33	Height
YSUM	Real	35	Sum of Y
YSUMSQ	Real	33	Sum of Y <sup>2</sup>

#### Subroutine GUTS

GUTS is called by INVENT to read the input data and calculate the basal area per acre, trees per acre, and all of the volumes along with their standard errors. GUTS also calculates the number of units sampled and the percent cruise. Either subroutine VOLMER or VOLTOT is called by GUTS repeatedly to calculate tree volume.

GUTS reads the input file specified by the variable IFILE and located on unit 21 (disk on DEC-10). It checks the range of input data in the same way LINREG does except that the minimum allowed DBH is set at the value of CLASIZ instead of 1.

GUTS checks the value of POINT on the first plot to see if POINT = -9. Such a value indicates the data is presented in summary mode (not tallied by individual plot) and therefore no statistical analysis of the sampling error can be made. It also indicates that the value of TREES is the number of plots sampled.

GUTS reads all the data accumulating sums of basal areas, number of trees, sawlog board foot volume, sawlog cubic foot volume, and pulpwood cubic foot volume. After all the data is read, the accumulated sums are expanded into per acre estimates based on the sampling technique used (point or plot). The variances and standard errors of these volumes are also calculated. Before

attempting to calculate variances, GUTS checks to see if more than one plot has been sampled. If not, GUTS sets itself into summary mode and does not attempt to calculate any variances or standard errors.

Common Areas Used: COMUNE, REG, and OUT1.

Other				
<u>Variables</u>	<u>Type</u>	<u>Dimension</u>		<u>Description</u>
DBVOL	Real	--		Board foot volume of a tree
BRDPT	Real	35		Sawlog bd.ft. volume of a sample unit
BRDSQ	Real	35		Sum of BRDPT <sup>2</sup>
CUBPT	Real	35		Sawlog cub.ft. volume of a sample unit
CUBSQ	Real	35		Sum of CUBPT <sup>2</sup>
CUBVOL	Real	--		Cubic foot volume of a tree
DBH	Int	--		Diameter at breast height
FACTOR	Real	--		Sample method expansion factor
HEIGHT	Real	--		Tree height
I	Int	--		DO loop index
IREP	Int	--		Number of reps on input
ISPEC	Int	--		Species loop counter
ISTART	Int	2		First of a forest type
ISTOP	Int	2		Last of a forest type
LOOP	Int	--		Loop counter
NPLOTS	Int	--		Number of plots sampled
PCTCRZ	Real	--		Percent cruise
PCTSAW	Real	--		Percent sawlog
PLTSIZ	Real	--		Fixed radius plot size
POINT	Int	--		Point number
PROD	Real(C*1)	--		Product code
PULPT	Real	35		Pulpwood cub.ft. volume of a sample unit
PULSQ	Real	35		Sum of PULPT <sup>2</sup>
PULVOL	Real	--		Pulpwood cub.ft. volume of a tree
REGWGT	Real	--		Weight for regression standard error
SPEC	Int(C*2)	--		Species input code
TRECNT	Int	40,32		Number of trees tallied by d.b.h.
TREES	Int	--		Number of trees on a sample unit
VARCUB	Real	--		Sawlog cub.ft. volume variance

#### Subroutine VOLMER

VOLMER is called by GUTS to calculate the merchantable cubic and board foot volume of individual trees when tree height is specified to a merchantable top. The input parameters are d.b.h., merchantable height, and species.

The cubic foot volume equations are from Barnard et al. (1969). To use these equations all species must be placed in one of seventeen groups. The species grouping is as follows:

<u>Species Group Number</u>	<u>Species in Group</u>
1	WP, RP, OH
2	SP
3	BF
4	HM
5	PP, TA, NS, SC
6	CE
7	SM
8	RM, YP
9	WA, AS
10	BC
11	WB, YB, SB, GB
12	BE
13	B
14	RO, BO, GU
15	WO, EL
16	HI
17	WI, HH, OH

— The board foot volume equation is from Wiant and Castenada (1977).

This equation is a formulation of the Mesavage and Girard (1946) form class tables. A form class must be specified for each of the 32 species. VOLMER sets the form classes to the following defaults:

Hemlock	70
All other softwoods	76
All hardwoods	74

The user can specify alternate form classes at execution time.

The cubic foot equations are based on a 4" merchantable top while the board foot equations are based on a 10" merchantable top. The equations are presented in full in Appendix C, pages 56 and 57.

Common Area Used: FORMCL.

<u>Other Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
BDHT	Real	--	Board ft. merchantable height in logs
BDVOL	Real	--	Board ft. volume of tree
CBHT	Real	--	Cubic ft. merchantable height in feet
CUBINT	Real	17	Cubic ft. volume equation intercept
CUBSLP	Real	17	Cubic ft. volume equation slope
CUBVOL	Real	--	Cubic ft. volume of tree
DBH	Int	--	Diameter at breast height
GRP	Int	32	Species group for cub.ft. volume equation
HEIGHT	Real	--	Tree height
I	Int	--	Implied DO loop index for data statements
ISPEC	Int	--	Species loop counter
WIANT	Real Function		Computes board foot volume

Subroutine VOLTOT

VOLTOT is called by GUTS to calculate the merchantable cubic and board foot volume of individual trees when total tree height is measured. The input parameters are d.b.h., total height, and species.

Both the cubic and board foot equations are from Honer (1967). In applying these formulas, the gross cubic foot volume of the tree is first calculated. The merchantable cubic and board foot volumes are then derived from the gross volume. To use these equations it is necessary to place all species into one of 16 groups. The species grouping is as follows:

<u>Species Group Number</u>	<u>Species in Group</u>
1	WP
2	RP, PP, TA, SC, OS
3	SP, NS
4	BF
5	CE
6	HM
7	AS
8	WB, SB, GB
9	YB
10	SM, RM, YP
11	BW
12	BE
13	BC
14	EL
15	WI, HH, OH
16	RO, WO, BO GU, HI, WA

Stump height and merchantable top are variables in the equations.

VOLTOT sets these to the following defaults:

Stump Height	0.5 ft.
Cubic Foot Top	4 in.
Softwood Board Foot Top	6 in.
Hardwood Board Foot Top	8 in.

The equations are presented in full in Appendix C, page 58.

No common area used.



<u>Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
ASDRBF	Real	3	Board foot volume equation coefficients
ASDRCF	Real	3	Cubic foot volume equation coefficients
BDVOL	Real	--	Sawlog bd.ft. volume of tree
BRDTOP	Real	2	Bd.ft. merchantable top diameter
CUBINT	Real	16	Cub.ft. volume equation intercept
CUBSLP	Real	16	Cub.ft. volume equation slope
CUBTOP	Real	2	Cub.ft. merchantable top diameter
CUBVOL	Real	--	Cubic ft. volume of tree
DBH	Int	--	Diameter at breast height
GRP	Int	32	Species group for volume equations
HEIGHT	Real	--	Tree Height
I	Int	--	Implied DO loop index for data statements
ISPEC	Int	--	Species loop counter
ITYPE	Int	--	Forest type indicator
STUMP	Real	--	Stump height
TCBVOL	Real	--	Total cubic foot volume
XBRD	Real	--	Intermediate step in bd.ft. volume calculation
XCUB	Real	--	Intermediate step in cub.ft. volume calculation

Subroutine STRAT

STRAT is called by INVENT if more than one stratum are being processed.

STRAT calculates combined strata statistics for sawlog cubic foot volumes, sawlog board foot volumes and pulpwood cubic foot volumes. These statistics include total volume over all strata along with their standard error and effective degrees of freedom. STRAT also calculates the total acreage of all the strata combined.

STRAT has two entry points, STRAT and STRAT2. STRAT is used as an entry point after each individual stratum is processed. Sums are accumulated for volumes, variances, and squared variances. STRAT2 is called after all of the strata have been processed. The previously accumulated sums are used to calculate total volumes, standard errors, and effective degrees of freedom.

Common Areas Used: OUT1 and STOUT.

Other

<u>Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
ACRES	Real	--	Acreage of compartment
CLASIZ	Int	--	Diameter class size
DBH	Int	--	Diameter at breast height
DFBD2	Real	32	Intermediate calculation in EFDFBD
DFCB2	Real	32	Intermediate calculation in EFDFCB
DFPL2	Real	32	Intermediate calculation in EFDFPL
ISPEC	Int	--	Species loop counter
STVMBD	Real	35	Sawlog bd.ft. variance
STVMCB	Real	35	Sawlog cub.ft. variance
STVMPL	Real	35	Pulpwood cub.ft. variance
I	Int	--	Implied DO loop index
J	Int	--	Implied DO loop index

### Subroutine OUTP1

OUTP1 is called by INVENT to produce all of the program's output. The subroutine has two entry points, OUTP1 and OUTP2. OUTP1 is used to produce the individual stratum output while OUTP2 is used to produce the stratified total output. All output is written to unit 3 (LPT on DEC-10) creating a file named INVENT.LPT.

OUTP1 produces the following output tables for each stratum:

1. Summary of job control related information (Table 1).
2. Analysis of the height-dbh relationship if regression option used (Table 17).
3. Individual stand and stock table for each species sampled (Tables 2, 3).
4. Stand and stock tables for Softwood summary, Hardwood summary, and All Species summary (Tables 4, 5, 6).
5. Table of species composition by percent (Table 7).
6. Table of volume totals for all species (Table 8).
7. Table of volume totals for all species expanded by acreage (Table 9).

The stand and stock tables include basal area/acre, trees/acre, sawlog cubic and board foot volumes per acre, and pulpwood cubic foot volume per acre, all presented by diameter class as well as a total over all diameters. A confidence interval expressed as a percent is given for each volume total. Also listed are mean stand diameter, merchantable m.s.d. (mean stand diameter of trees with dbh greater than or equal to 8 inches), percent cruise, sawlog board foot coefficient of variation, and pulpwood cubic foot coefficient of variation. Furthermore, the title of each compartment is printed on the top of each page and the pages are consecutively numbered.

OUTP2 is used as an entry point to produce the following stratified total output if more than one stratum were sampled:

1. Summary of job control related information (Table 10).
2. Volume tables for each species sampled (Table 11, 12).
3. Volume tables for Softwood summary, Hardwood summary, and All Species summary (Tables 13-15).
4. Table of volume totals for all species (Table 16).

All volume figures from OUTP2 are total volumes expanded over the entire acreage of all the strata combined. The individual species tables and the three summary tables list volumes by diameter class as well as giving a total over all diameters. A confidence interval expressed as a percent is given for each volume total. Each page of the output is consecutively numbered and a specified title is printed at the top of each page.

Both OUTP1 and OUTP2, when producing individual species tables, will print the form class used to calculate board foot volume next to the species title if the trees were measured to a merchantable top. Otherwise, no form class information is printed.

Common Areas Used: COMUNE, FORMCL, OUT1, REG, and STOUT.

Other Variables	Type	Dimension	Description
AFCNUM	Real(C*2)	--	Form class number as a literal
AFCTIT	Real(C*5)	--	Output title
ALPHA	Real	--	Confidence level as a decimal
BASCOM	Real	--	Percentage of basal area
BDCOM	Real	--	Percentage of sawlog bd.ft. volume
CUBCOM	Real	--	Percentage of sawlog cub.ft. volume
DBH	Int	--	Diameter at breast height
DF	Real	--	Degrees of freedom
I	Int	--	Implied DO loop index for data statements
IBDCV	Int	--	Board ft. coefficient of variation
IBDTST	Int	--	Total sawlog bd.ft. volume all strata
IBDVST	Int	--	Total sawlog bd.ft. volume all strata by dbh
ICBTST	Int	--	Total sawlog cb.ft. volume all strata
ICBVST	Int	--	Total sawlog bd.ft. volume all strata by dbh
IDATE	Int(C*5)	2	Date
IERBRD	Int	--	Percent error in sawlog bd.ft. volume
IERCUB	Int	--	Percent error in sawlog cb.ft. volume
IERPUL	Int	--	Percent error in pulpwood cb.ft. volume
IFLAG	Int	--	Warning message flag
IPAGE	Int	--	Page number
IPLCV	Int	--	Pulpwood coefficient of variation
IPLTST	Int	--	Total pulpwood cb.ft. volume all strata
IPLVST	Int	--	Total pulpwood cb.ft. volume all strata by dbh
ISPEC	Int	--	Species loop counter
ISTRA	Int	--	Number of strata sampled
J	Int	--	Implied DO loop index
MSD	Real	--	Mean stand diameter
OFRAME	Real(C*5)	--	Saves the contents of FRAME
PCTCRZ	Real	--	Estimated percent cruise for point sampling
PULCOM	Real	--	Percentage of pulpwood volume
RBSTOT	Real	--	Basal area of trees with dbh $\leq$ 8"
REGUSE	Real(C*4)	--	Output message
RMSD	Real	--	Merchantable mean stand diameter
RTRTOT	Real	--	Trees/acre of trees with dbh $\leq$ 8"
SPETIT	Int(C*5)	35,3	Species titles for output

<u>Other Variables</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
TOTABD	Int	--	Total sawlog bd.ft. volume
TOTACB	Int	--	Total sawlog cb.ft. volume
TOTAPL	Int	--	Total pulpwood volume
TOTPTS	Int	--	Total number of sample units
TRECOM	Real	--	Percentage of trees/acre
TVAL	Real	--	t-value

Subroutines MDSTI and MDNRIS

MDSTI and MDNRIS are adapted from the International Mathematical and Statistical Libraries, Inc. (IMSL). Both subroutines have been edited removing capabilities not needed in this application. The remaining code is reproduced in Appendix E in accordance with the IMSL policy on research work as stated on page INTRO-22 of the July, 1977 IMSL library manual.

MDSTI is called by OUTP1 to calculate the percentage point of the Student's t distribution. MDNRIS is called by MDSTI and is used to evaluate the inverse normal probability distribution function. MDSTI gives 5 significant digit accuracy (IMSL 1977). Furthermore, table 26.10, p. 999 of the Handbook of Mathematical Functions edited by Abramowitz and Stegun was duplicated by MDSTI (IMSL 1977).

No variable dictionary is presented. The interested reader may refer to pages MDSTI-1, MERFI/MERFCI/MDNRIS-1, and MERFI/MERFCI/MDNRIS-2 of the 1977 IMSL Library manual.

#### SECTION 4. STATISTICAL ANALYSIS

##### Overview

The purpose of INVENT's statistical analysis is to indicate the reliability of the volume estimates. This is accomplished by computing a confidence interval for all volume estimates that are summed across the diameter classes. This confidence interval is specified as a percent of the respective volume estimate. The user specifies the confidence level as a decimal in the range .65 to .99. All statistical analysis assumes a stratified random sample where each sample unit is a cluster. There is an option to double sample for height within the clusters.

INVENT calculates confidence intervals for sawlog cubic foot volume, sawlog board foot volume, and pulpwood cubic foot volume. The analysis for each volume is carried out independently of the other volumes. Since the method is exactly the same for each volume, the calculation of error for an arbitrary volume  $V$  is presented. Throughout the discussion we will assume the reader is familiar with the techniques for calculating the mean volume per acre when the heights of all volume trees are measured. (Cf. Barrett and Nutt, 1975; Avery, 1975; Husch, Miller, and Beers, 1972; Dillworth and Bell, 1976.)

The statistical analysis is presented in the same sequence as the program performs it. For each individual stratum the standard error of the volume must be calculated. If the height subsampling option is used, the program first calculates the standard error due to height estimation. Next the percent cruise of the stratum is calculated. This is used to refine the standard error due to the variation between clusters which is calculated next. This standard error is then combined with the height estimation standard error to give the volume standard error of the stratum. Finally, the volume standard errors of all the strata are combined to yield the standard error of the stratified volume estimate along with the effective degrees of freedom of that estimate.

Standard Error of Height Estimation

INVENT allows the user to double sample within each cluster for tree height. For each species where three or more height trees are measured within the stratum, a regression relationship between height and the inverse of d.b.h. is analysed. When calculating volume for a tree whose height was not measured, the regression equation is used to generate a height for that tree. If the user were required to measure the heights of all trees on some of the clusters while measuring no heights on the remaining clusters, the volume standard error could be calculated using techniques developed by Donald Bruce (1961) and Floyd A. Johnson (1958). Bruce's method is outlined in Appendix B, page 53. Johnson's method is an application of double sampling with ratio of means estimation and this method is presented in Appendix B, page 52. Neither method is applicable if the user is free to subsample a portion of the trees within each cluster. A new statistical technique was developed to approximate the standard error of the resulting volume estimate.

The authors believe that this new technique is far more efficient in field application. It allows the user to sample heights more intensely on the more valuable species. It provides far more flexibility than the traditional approach.

H = height      D = d.b.h.      T = # trees sampled      t = # height trees sampled

Regression Model:  $H = B_0 + B_1 \left(\frac{1}{D}\right) + \epsilon$

$$\text{Variance (H)} = S_H^2 = \frac{\text{MSE}}{t}$$

where MSE = mean square error of the regression (for computational formula see Neter and Wasserman, 1974, p. 45).

$$\text{Standard Error (H)} = SE_H = \frac{S_H}{\bar{H}} \quad (100)$$

$SE_H$  is calculated for every species where three or more height trees are measured. It is also necessary to calculate  $SE_H$  for the Softwood, Hardwood and All Species summary volumes. The method used is from Neter and

Wasserman pp. 163-4 (1974). It is equivalent to fitting a regression for each of the three groups using pooled data from each species in the group. However the method used is far more efficient. We simply define  $T^*$ ,  $t^*$ , and  $MSE^*$  for each summary group as a function of  $T$ ,  $t$ , and  $MSE$  for every species in that group. For instance, suppose we want  $SE_H$  for hardwoods where the hardwood group in this stratum consists of three species. Then,

$$T^* = T_1 + T_2 + T_3$$

$$t^* = t_1 + t_2 + t_3$$

$$MSE^* = \frac{MSE_1(t_1-2) + MSE_2(t_2-2) + MSE_3(t_3-2)}{(t_1-2) + (t_2-2) + (t_3-2)}$$

Using these new values,  $SE_H$  is calculated as before.

#### Percent Cruise

Percent cruise is simply the percent of the population actually sampled. When sampling with fixed-radius plots, percent cruise is easily calculated as follows:

Let  $P$  = percent cruise  
 $PLT$  = plot size in acres  
 $n$  = number of plots sampled  
 $AC$  = tract size in acres

Then, 
$$P = \frac{n \cdot PLT}{AC} \quad (100)$$

When sampling with variable-radius plots (point sampling) the true value of  $P$  is unknown. However, based on our sample estimate of  $MSD$  we can estimate the value of  $P$  (Cunia, 1959).

Let  $P$  = percent cruise  
 $n$  = number of sample points  
 $AC$  = tract size in acres  
 $BAF$  - basal area factor of angle used  
 $B$  = total basal area of all trees on tract  
 $T$  = total number of trees on tract  
 $MSD$  = mean stand diameter (quadratic mean)

Then, 
$$P = \frac{100 \cdot n \cdot B}{T \cdot AC \cdot BAF} = \frac{0.5454 \cdot n \cdot MSD^2}{AC \cdot BAF}$$

It should be noted that in a variable-radius cruise, the percent cruise may be different for each species. See tables 2 and 3.

In forest sampling, we deal with finite populations. The formula we use to estimate the variance of the mean volume per acre for each stratum includes a term known as the finite population correction (FPC). The FPC reduces the variance of the mean when a significant (usually > 5 percent) portion of the population has been sampled.

Let  $N$  = number of sample units in population

$n$  = number of units actually sampled

$$\text{Then, FPC} = \frac{N - n}{N}$$

In plot sampling  $N = \frac{AC}{PLT}$  and  $n$  = number of plots sampled. However, in point sampling there is no easy way to calculate  $N$ . Therefore, mensurationists have traditionally ignored the FPC when analysing point cruises. This can be quite inefficient when tract sizes are small as is often the case in New Hampshire. This problem can be easily overcome using the previous result permitting the calculation of percent cruise when point sampling. It can easily be shown that the FPC is simply a function of  $P$  (percent cruise).

$$\text{FPC} = \frac{N - n}{N} = \frac{N}{N} - \frac{n}{N} = 1 - \frac{n}{N} = 1 - \frac{P}{100}$$

INVENT uses this relationship to refine the variance estimates when point sampling as well as plot sampling. INVENT calculates FPC as  $1 - \frac{P}{100}$ .

The standard error due to the variation in volume between clusters,  $SE_{\bar{Y}}$ , is calculated as follows:

$\bar{Y}$  = mean volume/acre of stratum

$S^2$  = sample variance of volume

$n$  = number of sample units

$$\text{then, } SE_{\bar{Y}} = \sqrt{\frac{S^2}{n}} \left[ \frac{1}{\bar{Y}} \right] \quad (100) \quad (\text{FPC})$$

If the height of all volume trees was measured, then  $SE_{\bar{Y}}$  is the standard error of the volume estimate for the stratum,  $SE_{VOL}$ . If, however, the



height double sampling option was used,  $SE_{VOL}$  must reflect both  $SE_{\bar{Y}}$  and  $SE_H$ , the standard error due to height estimation. In this case,  $SE_{VOL}$  is calculated as follows:

$$SE_{VOL} = \sqrt{SE_{\bar{Y}}^2 + \frac{(T - t)}{T} (SE_H^2)}$$

Combined Strata Statistics

We have seen how INVENT calculates the mean volume/acre with its standard error for each stratum in the sample. The final step in the statistical analysis is to use the individual stratum statistics to calculate the total volume across all strata along with the standard error.

- Let  $L$  = number of strata sampled
- $AC_i$  = size of stratum  $i$  in acres
- $N_i$  = number of sample units in stratum  $i$
- $n_i$  = number of units sampled in stratum  $i$
- $\bar{Y}_i$  = mean volume per acre of stratum  $i$
- $VOL_i$  = total volume of stratum  $i$  =  $AC_i \cdot \bar{Y}_i$
- $SE_{VOL_i}$  = volume standard error of stratum  $i$  as a percent
- $S_{VOL_i}^2$  =  $(SE_{VOL_i}^2 \cdot VOL_i^2) / 100^2$  = variance of total volume

then we calculate the stratified total statistics as follows:

$$AC = \sum_{i=1}^L AC_i = \text{total acreage sampled}$$

$$VOL = \sum_{i=1}^L VOL_i = \text{stratified total volume}$$

$$SE_{VOL} = \frac{\sqrt{\sum_{i=1}^L S_{VOL_i}^2}}{VOL} \quad (100)$$

Having calculated  $VOL$  and  $SE_{VOL}$ , all that remains in calculating the confidence interval is determining the appropriate percentage point of the Student's  $t$  distribution. In order to do this we must calculate the degrees of freedom associated with  $S_{VOL}^2$ . Satterthwaite (1946) states that the exact distribution of the complex estimate  $S_{VOL}^2$  is too involved for

everyday use. He suggests approximating the true distribution with a Chi-square distribution of equal variance. Cochran (1977 p. 96) uses this approach and defines the degrees of freedom of the approximating Chi-square as:

$$DF_{\text{eff}} = \frac{\left[ \sum_{i=1}^L g_i S_i^2 \right]^2}{\sum_{i=1}^L \frac{g_i^2 S_i^4}{n_i - 1}} \quad \text{where } g_i = \frac{N_i (N_i - n_i)}{n_i}$$

$S_i^2 = \text{sample variance}$

A more appropriate form for our purposes is given by

$$DF_{\text{eff}} = \frac{\left[ \sum_{i=1}^L S_{VOL_i}^2 \right]^2}{\sum_{i=1}^L \frac{S_{VOL_i}^4}{n_i - 1}}$$

The equivalence of the two formulas is shown in Appendix B, page 54.

Using this result the appropriate value  $t$  is derived from the Student's  $t$  distribution and the confidence interval is given by:

$$VOL \pm t \cdot SE_{VOL}$$

APPENDIX A

DATA CODING INFORMATION

EXAMPLES OF TREE CODING OPTIONS

COLUMN:	SPECIE CODE		DIAMETER		PRODUCT CODE		HEIGHT		REPLICATIONS			PERCENT SAWLOG		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sawlog only Height in logs	W	P		1	6	S	2	.	0		2			
Sawlog only Height in feet	R	P		1	8	S		4	8		1			
Pulpwood only Height in feet	B	E		1	0	P		2	0		1			
Mixed product Height in logs	R	O		1	6	%	2	.	0		3		5	0
Mixed product Height in feet	S	P		2	2	%		6	4		1		6	0
SawLog only Height in logs Default specification of reps and product.	H	M		1	2		1	.	0					

INVENT SPECIES LIST

WHITE PINE	WP
RED PINE	RP
PITCH PINE	PP
HEMLOCK	HM
BALSAM FIR	BF
TAMARACK	TA
SPRUCE	SP
NORWAY SPRUCE	NS
SCOTCH PINE	SC
CEDAR	CE
OTHER SOFTWOODS	OS
SUGAR MAPLE	SM
RED MAPLE	RM
ASH	WA
WILLOW	WI
ASPEN	AS
YELLOW POPLAR	YP
BLACK CHERRY	BC
WHITE BIRCH	WB
YELLOW BIRCH	YB
SWEET BIRCH	SB
GREY BIRCH	GB
BEECH	BE
BASSWOOD	BW
RED OAK	RO
WHITE OAK	WO
BLACK OAK	BO
ELM	EL
GUM	GU
HICKORY	HI
HOPHORNBEAM	HH
OTHER HARDWOODS	OH



INVENT DATA FILE

WHITAKER WOODS 1978 COMP. 1  
01 11  
RP 14 3.0  
WP 20 4.0  
RP 14 3.5  
WP 18 4.0  
WP 12 3.0  
WP 18 3.5  
WP 16 3.0  
WP 20 4.0  
WP 22 4.5  
WP 22 4.5  
RP 16 3.0  
02 12  
WP 12 2.5  
WP 20 3.5  
WP 32 4.0  
RP 16 3.0  
BE 10 1.0  
BE 06FO.5 2  
WP 16 3.5  
WP 16 4.0  
WP 12 2.0  
RP 16 3.0  
WP 26 4.0  
03 09  
WP 26 4.0  
WP 32 4.5  
RP 22 3.5  
RP 18 3.5  
RO 14 1.0  
RO 22 1.0  
RO 18 1.0  
WP 26 5.0 2  
04 14  
WP 22 4.0  
WP 30 4.0  
WP 30 4.0  
WP 20 3.5  
WP 20 4.0 2  
WP 26 4.5  
WP 16 4.0  
WP 18 4.5  
WP 18 3.0  
WP 20 4.5  
WP 28 4.5  
WP 32 4.0  
WP 20 4.5  
05 13  
WP 24 3.0  
RP 16 2.0  
WP 32 4.0  
WP 26 3.5  
RO 12 1.0  
HM 18 1.5  
HM 16 1.0  
RP 12 1.0  
RP 10 1.0  
RO 16 1.0 2  
WP 14 2.5  
HM 18 2.0

INVENT Processing Request Form

Forester Information:

Name: \_\_\_\_\_

Firm Name: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

Tract Information:

Number of compartments: \_\_\_\_\_

Do you wish to use alternate form classes? \_\_\_\_\_ ( yes or no )

If yes enter form classes below.

WP\_\_\_\_ RP\_\_\_\_ PP\_\_\_\_ HM\_\_\_\_ BF\_\_\_\_ TA\_\_\_\_ SP\_\_\_\_ NS\_\_\_\_

SC\_\_\_\_ CE\_\_\_\_ OS\_\_\_\_ SM\_\_\_\_ RM\_\_\_\_ WA\_\_\_\_ WI\_\_\_\_ AS\_\_\_\_

YP\_\_\_\_ BC\_\_\_\_ WB\_\_\_\_ YB\_\_\_\_ SB\_\_\_\_ GB\_\_\_\_ BE\_\_\_\_ BW\_\_\_\_

RO\_\_\_\_ WO\_\_\_\_ BO\_\_\_\_ EL\_\_\_\_ GU\_\_\_\_ HI\_\_\_\_ HH\_\_\_\_ OH\_\_\_\_

Diameter class size \_\_\_\_\_

INVENT uses the 95% confidence level as a default. If you wish to use a different level, please specify \_\_\_\_\_ (65 - 99)

Tract Description (up to 70 characters)

: \_\_\_\_\_



INVENT      Compartment Information Form

Compartment Name and/or Description (up to 70 characters)

: \_\_\_\_\_

Sampling Method \_\_\_\_\_ ( Point, Plot, Strip, or 100%)

If Point: BAF = \_\_\_\_\_

If Plot : Plot size = \_\_\_\_\_ acres

If Strip: Total acreage of all strips = \_\_\_\_\_ acres

Tree Height Measurement Units \_\_\_\_\_ ( 16 ft. logs or feet )

Tree top specification \_\_\_\_\_ ( merchantable, total, or mixed )

Were the heights of all volume trees measured? \_\_\_\_\_ ( yes or no )

Acreage of compartment: \_\_\_\_\_ acres



APPENDIX B

STATISTICAL FORMULAS AND DERIVATIONS

DOUBLE SAMPLING WITH RATIO OF MEANS EXPANSION

- $X_i$  = Basal area per acre at cluster  $i$   
 $Y_i$  = Volume per acre at cluster  $i_j$   
 $N$  = Number of possible sample units  
 $n$  = Total number of units sampled  
 $n_o$  = Number of volume units sampled  
 $\bar{X}$  = Average basal area of all units sampled  
 $\bar{X}_o$  = Average basal area of the volume units sampled  
 $\bar{Y}_o$  = Average volume of the volume units sampled  
 $\bar{Y}_r$  = Ratio estimate of the mean volume per acre

$$B = \frac{\bar{Y}_o}{\bar{X}_o}$$

$$\bar{Y}_r = B \cdot \bar{X}$$

$$S_{Y_r}^2 = \left( \frac{n_o - n}{n_o} \right) \left( \frac{\bar{X}_o}{\bar{X}} \right)^2 \left( \frac{S_Y^2 + B^2 S_X^2 - 2BS_{XY}}{n} \right) + \frac{S_Y^2}{n_o} \left( \frac{N - n_o}{N} \right)$$

STATISTICAL ANALYSIS OF A VARIABLE PLOT CRUISE USING BRUCE'S METHOD

(Bruce 1961)

Notation

- $\gamma$  - volume points
- $\alpha$  - all points
- $n$  - number of points
- TC - tree count
- VBAR - volume to basal area ratio
- VOL - volume per acre
- SE - standard error expressed as a percent
- CF - correction factor

Example of Notation:

$SE_{TC_\alpha}$  - standard error of the tree count on all points expressed as a percent

$$\text{Estimated volume} = VOL_\gamma \cdot \left[ \frac{TC_\alpha / n_\alpha}{TC_\gamma / n_\gamma} \right] = (VOL_\gamma \cdot TC_\alpha \cdot n_\gamma) / (TC_\gamma \cdot n_\alpha)$$

$$\text{Uncorrected standard error} = \sqrt{SE_{VBAR_\gamma}^2 + SE_{TC_\alpha}^2}$$

Corrected standard error = CF · (uncorrected standard error)

$$\text{where CF} = \frac{SE_{VOL_\gamma}}{\sqrt{SE_{VBAR_\gamma}^2 + SE_{TC_\gamma}^2}}$$

FORMULA FOR EFFECTIVE DEGREES OF FREEDOM

$$DF_{eff} = \frac{\left( \sum_{i=1}^L g_i S_i^2 \right)^2}{\sum_{i=1}^L \frac{g_i^2 S_i^4}{n_i - 1}} \quad \text{where } g_i = \frac{N_i (N_i - n_i)}{n_i}$$

$$= \frac{\left( \sum_{i=1}^L \frac{N_i (N_i - n_i)}{n_i} S_i^2 \right)^2}{\sum_{i=1}^L \frac{\left( \frac{N_i (N_i - n_i)}{n_i} \right)^2 S_i^4}{n_i - 1}}$$

$$= \frac{\left( \sum_{i=1}^L \frac{S_i^2}{n_i} \cdot \frac{(N_i - n_i) N_i^2}{N_i} \right)^2}{\sum_{i=1}^L \frac{\left( \frac{S_i^2}{n_i} \cdot \frac{(N_i - n_i)}{N_i} \right)^2 N_i^4}{n_i - 1}}$$

$$= \frac{\left( \sum_{i=1}^L \frac{S_{Y_i}^2 \cdot N_i^2}{n_i} \right)^2}{\sum_{i=1}^L \frac{S_{Y_i}^4 \cdot N_i^4}{n_i - 1}} = \frac{\left( \sum_{i=1}^L S_{VOL_i}^2 \right)^2}{\sum_{i=1}^L \frac{S_{VOL_i}^4}{n_i - 1}}$$

APPENDIX C

VOLUME FORMULAS

CUBIC FOOT VOLUME EQUATIONS  
BASED ON MERCHANTABLE HEIGHT  
(Barnard et al. 1973)

General form of equation:  $VOLUME = a + b (DBH^2 \cdot HEIGHT)$

where height is measured to a 4" top in ft.

<u>Species Group</u>	<u>a</u>	<u>b</u>
1	3.5142	0.00236
2	2.1998	.00257
3	1.4793	.00272
4	2.4784	.00242
5	-0.0496	.00303
6	1.5817	.00259
7	1.6823	.00310
8	1.1763	.00310
9	1.0067	.00293
10	1.1809	.00292
11	1.1339	.00281
12	1.2851	.00326
13	0.8976	.00349
14	1.2027	.00301
15	1.0009	.00300
16	1.4438	.00316
17	0.8591	.00309

For the species composition of each group see page 31.



BOARD FOOT VOLUME EQUATION  
BASED ON MERCHANTABLE HEIGHT  
(Wiant and Castenada 1978)  
(INT. 1/4-inch Rule)

D = diameter at breast height  
H = merchantable height to a 10" top in 16 foot logs  
FC = Girard form class

$$\text{VOLUME} = [(a_0 + a_1 H + a_2 H^2) + (b_0 + b_1 H + b_2 H^2)D + (c_0 + c_1 H + c_2 H^2)D^2] [(FC - 78)(.03) + 1]$$

where

$a_0$	=	-13.35212
$a_1$	=	9.58615
$a_2$	=	1.52968
$b_0$	=	1.79620
$b_1$	=	-2.59995
$b_2$	=	-0.27465
$c_0$	=	0.04482
$c_1$	=	0.45997
$c_2$	=	-0.00961

CUBIC AND BOARD FOOT VOLUME EQUATIONS

BASED ON TOTAL HEIGHT

(Honer 1967)

(INT. 1/4-inch Rule)

- D = diameter at breast height
- H = total height in feet
- GCVL = gross cubic foot volume
- MCVL = merchantable cubic foot volume
- MBVL = merchantable board foot volume
- STH = stump height
- CTOP = cubic foot merchantable top diameter
- BTOP = board foot merchantable top diameter

Equations:

$$GCVL = \frac{D^2}{a_0 + \frac{a_1}{H}}$$

$$X = \left[ \frac{CTOP^2}{D^2} \right] \left[ \frac{H + STH}{H} \right]$$

$$MCVL = [b_0 + b_1 X + b_2 X^2] \cdot GCVL$$

$$Y = \left[ \frac{BTOP^2}{D^2} \right] \left[ \frac{H + STH}{H} \right]$$

$$MBVL = [c_0 + c_1 Y + c_2 Y^2] \cdot GCVL$$

where

- STH = 0.5 ft.
- CTOP = 4.0 in. for all species
- BTOP = 6.0 in. for softwoods  
8.0 in. for hardwoods
- b<sub>0</sub> = 0.9604
- b<sub>1</sub> = -0.1660
- b<sub>2</sub> = -0.7868
- c<sub>0</sub> = 5.4332
- c<sub>1</sub> = -1.6281
- c<sub>2</sub> = -4.4710

Species Group	a <sub>0</sub>	a <sub>1</sub>
1	0.691	363.676
2	0.710	355.623
3	1.226	315.832
4	2.139	301.634
5	4.167	244.906
6	1.112	350.092
7	-0.312	436.683
8	2.222	300.373
9	1.449	344.754
10	1.046	383.972
11	0.948	401.456
12	0.959	334.829
13	0.033	393.336
14	0.634	440.496
15	1.877	332.585
16	1.512	336.509

For the species composition of each group see page 32.

APPENDIX D

INVENTORY DESIGN AND SAMPLE SIZE ESTIMATION

### Inventory Design

INVENT analyzes data based on two sampling designs:

- (1) simple random sampling,
- (2) stratified random sampling with simple random sampling within each stratum.

Sampling is assumed without replacement--that is, sample units (plots or points) are far enough apart so that a tree is sampled on only one sample unit.<sup>1</sup>

INVENT allows for the possibility of double sampling regression estimation of volume. The error associated with regression estimation is small relative to the error among sample units. Thus, it is ignored in the discussion given below on sample size approximation.

Foresters commonly use systematic sampling rather than simple random sampling. Generally, estimates from systematic sampling are somewhat more precise than from simple random sampling provided the systematic sample units are spread well over the tract sampled. Therefore, confidence intervals based on simple random equations provide somewhat conservative estimates for well-representative systematically collected data. For the same reason, sample size is usually overestimated.

### Sample Size

Sample size is treated briefly. More detailed explanations are given in Barrett and Nutt (1975), Cochran (1977), Freese (1962), and Dilworth and Bell (1976).

---

<sup>1</sup>If a tree is sampled on more than one sample unit, the estimated means are still unbiased but the variance is underestimated.

Simple Random Sample

Sample size from simple random sampling is estimated by the following equation:<sup>2</sup>

$$n = \left[ \frac{t \text{ CV}}{E} \right]^2 \qquad \text{Equation 1}$$

where t is a t-value, CV is the coefficient of variation, and E is the allowable error in percent.

The t-value depends on the confidence level desired. The approximate t-values for the most widely used confidence levels are:

Confidence level (percent)	t-value
80	1.3
90	1.7
95	2.0
99	2.7

The coefficient of variation is a measure of the variability among volume estimates in a forest based on a particular technique of sampling.

Assume that from past experience a forester estimates that the coefficient of variation is 50 percent when he samples with a 10 B.A.F. prism. He wants to estimate the volume on a tract with an allowable error of 10 percent at the 95 percent confidence level. That is, he wants the chances to be 95 in 100 that his estimate after completing the inventory is within 10 percent of the actual volume.<sup>3</sup>

The sample size by Equation 1 is estimated as follows:

$$n = \left[ \frac{t \text{ CV}}{E} \right]^2 = \left[ \frac{2 (50)}{10} \right]^2 = 100 \text{ points}$$

Thus, the forester must select 100 points.

<sup>2</sup> The estimate of sample size using simple random and the subsequent estimates using stratified random sampling can be adjusted by the equation

$$n_a = \frac{n}{1 + P/100}$$

where P is the percent cruise. This additional refinement in estimating sample size is generally not necessary except on small tracts.

<sup>3</sup>To be within 10 percent of the actual volume implies that errors such as tree measurement errors, errors in estimating form class, and errors in volume equations are negligible.

Stratified Random Sampling

Often a forester divides the area into compartments or stands before beginning the inventory. In other words he stratifies the area.

If the forester's primary interest is in the estimates within each stratum, then he can specify the allowable error for each stratum and apply Equation 1 to estimate sample size.

If his primary interest is in the mean volume per acre or total volume over all strata, then he can estimate sample size by one of two techniques. Each technique depends on how sample units are allocated to strata. The two techniques will be illustrated with an example.

First consider proportional allocation. By proportional allocation, the forester determines sample size and allocates sample units to strata in proportion to the acreage of each stratum. The equation for sample size is

$$n = \left[ \frac{t}{E} \right]^2 \sum_{i=1}^L W_i CV_i^2 \quad \text{Equation 2}$$

where t is the t-value, E is the allowable error,  $W_i$  is the proportion of acreage in stratum i,  $CV_i$  is the coefficient of variation in stratum i, and L is the total number of strata.

Assume a forester has the following information on an 80-acre tract he wishes to sample with a 10-B.A.F. prism.

Stratum	Acreage	$W_i$	$CV_i$	$W_i CV_i^2$
1. small pines	36	.450	30	405.00
2. large pines	18	.225	50	562.50
3. mixed pine-hardwood	26	.325	80	2080.00
Totals	80	1.000	--	3047.50

Suppose he wants to estimate the mean volume per acre within 10 percent with 95 percent confidence. Then, by applying equation 2, he estimates the number of points required.

$$n = \left[ \frac{t}{E} \right]^2 \sum_{i=1}^L W_i CV_i^2 = \left[ \frac{2}{10} \right]^2 (3047.50) = 122 \text{ points}$$

He would allocate points to strata as follows:

Stratum	$W_i$	$n \cdot W_i$
1	.450	55
2	.225	27
3	.325	40
Totals	1.000	122

By the second technique of allocation, called Neyman allocation, the forester takes into account the coefficient of variation as well as the relative acreage in each stratum in assigning sample units to strata. Neyman allocation minimized the number of sample units required to achieve a specified precision. The equation for sample size is

$$n = \left[ \frac{t}{E} \right]^2 \cdot \left[ \sum_{i=1}^L W_i CV_i \right]^2 \quad \text{Equation 3}$$

To apply this equation to the data given above we require the following computations:

Stratum	$W_i$	$CV_i$	$W_i CV_i$
1	.450	30	13.50
2	.225	50	11.25
3	.325	80	26.00
Totals	1.000	--	50.75

Assuming an allowable error of 10 percent with 95 percent confidence, the forester estimates the number of points required.

$$n = \left[ \frac{t}{E} \right]^2 \left[ \sum_{i=1}^L W_i CV_i \right]^2 = \left[ \frac{2}{10} \right]^2 (50.75)^2 = 103 \text{ points}$$

The points are allocated to strata as follows:

Stratum	$W_i CV_i$	$n \cdot W_i CV_i / \sum_{i=1}^L W_i CV_i$
1	13.50	27
2	11.25	23
3	26.00	53
Totals	50.75	103

Proportional and Neyman allocation are two of the most common allocations. Other techniques of allocation are given in the references cited.





APPENDIX E

PROGRAM LISTING

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C                                     HAIN0010
PROGRAM INVENT                       HAIN0020
C                                     HAIN0030
C*****                             HAIN0040
C                                     HAIN0050
C INVENT VER. 3 1/1/79 DAVID S. LINDEH I. N. E. R. U. N. H. HAIN0060
C                                     HAIN0070
C                                     HAIN0080
C THIS IS THE MAIN PROGRAM OF INVENT HAIN0090
C IT PROVIDES TWO WAY USER COMMUNICATION AND SUBROUTINE CONTROL HAIN0100
C                                     HAIN0110
C*****                             HAIN0120
DOUBLE PRECISION IFILE,SAMHTD,REPEAT HAIN0130
INTEGER LOGANS, TOPANS, CLASIZ, REGANS, TITLE(14) HAIN0140
COMMON/COMUNE/CLASIZ, TITLE, MOLT, PROBLV, BAF, TOPANS, REGANS, ACRES HAIN0150
1, FRAME, SAMHTD, LOGANS, IFILE HAIN0160
DATA PROBLV/.05/ HAIN0170
C OPEN OUTPUT FILE HAIN0180
OPEN(UNIT=3, ACCESS='SEQOUT', FILE='INVENT.LPT') HAIN0190
C                                     HAIN0230
C *****                             HAIN0210
C USER COMMUNICATION PORTION HAIN0220
C *****                             HAIN0230
C                                     HAIN0240
C ASK USER IF HE WANTS TO USE ALTERNATE P.C.'S HAIN0250
10 WRITE(5,20) HAIN0260
20 FORMAT('DO YOU WANT TO READ IN ALTERNATE FORM CLASSES ', HAIN0270
1'FROM DISK?') HAIN0280
READ(5,270) PRMANS HAIN0290
IF (PRMANS.EQ.'YES') CALL PRMCLS HAIN0300
IF (PRMANS.NE.'NO'.AND.PRMANS.NE.'YES') GOTO 10 HAIN0310
C HAVE USER SPECIFY DBH CLASS SIZE HAIN0320
WRITE(5,30) HAIN0330
30 FORMAT('ENTER DIAMETER CLASS SIZE') HAIN0340
READ(5,*) CLASIZ HAIN0350
C HAVE USER SPECIFY NUMBER OF STRATA HAIN0360
WRITE(5,40) HAIN0370
40 FORMAT('ENTER NUMBER OF STRATA') HAIN0380
READ(5,*) ISTRAT HAIN0390
C ASK USER FOR NEW VALUE OF ALPHA IF DESIRED HAIN0400
50 WRITE(5,60) HAIN0410
60 FORMAT('OINVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.'/ HAIN0420
1' DO YOU WISH TO USE A DIFFERENT LEVEL?') HAIN0430
READ(5,270) ALPHCH HAIN0440
IF (ALPHCH.NE.'YES'.AND.ALPHCH.NE.'NO') GOTO 50 HAIN0450
IF (ALPHCH.EQ.'NO') GOTO 90 HAIN0460
70 WRITE(5,80) HAIN0470
80 FORMAT(' ENTER CONFIDENCE LEVEL AS A DECIMAL IN THE RANGE ', HAIN0480
1'.65 TO .99') HAIN0490
READ(5,*) ALPHA HAIN0500
IF (ALPHA.GT.0.99.OR.ALPHA.LT.0.65) GOTO 70 HAIN0510
PROBLV=1.0-ALPHA HAIN0520
90 CONTINUE HAIN0530
C                                     HAIN0540
C-----BEGIN PROGRAM CONTROL LOOP----- HAIN0550
C                                     HAIN0560
C DO 310 III=1,ISTRAT HAIN0570
C                                     HAIN0580
C HAVE USER SPECIFY INPUT FILE HAIN0590
WRITE(5,100) III HAIN0600
100 FORMAT('ENTER INPUT FILE NAME FOR STRATUM # ',I3) HAIN0610
READ(5,110) IFILE HAIN0620
110 FORMAT(A10) HAIN0630
C OPEN INPUT FILE HAIN0640
OPEN(UNIT=21, ACCESS='SEQIN', FILE=IFILE) HAIN0650
C READ INVENTORY TITLE FROM FILE HAIN0660
READ(21,120) TITLE HAIN0670
120 FORMAT(14A5) HAIN0680
C WRITE TITLE ON TERMINAL HAIN0690
WRITE(5,130) TITLE HAIN0700
130 FORMAT('0',14A5//) HAIN0710
SVFRAM=FRAME HAIN0720
C HAVE USER SPECIFY SAMPLING METHOD HAIN0730
IF (III.GT.1) REPEAT=' OR SAME' HAIN0740
140 WRITE(5,150) REPEAT HAIN0750
150 FORMAT('OSPECIFY SAMPLING METHOD'/ TYPE POINT OR PLOT',A8) HAIN0760
READ(5,240) FRAME HAIN0770
IF (FRAME.EQ.'SAME'.AND.III.GT.1) 160, 170 HAIN0780

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160 FRAME=SVFRAM                                MAIN0790
    GOTO 280                                    MAIN0800
170 IF (FRAME.NE.'POINT'.AND.FRAME.NE.'PLOT') GOTO 140 MAIN0810
    IF (FRAME.EQ.'POINT') SAMMTD='B.A.F.'      MAIN0820
    IF (FRAME.EQ.'PLOT') SAMMTD='PLOT SIZE'    MAIN0830
C HAVE USER SPECIFY BAF OR PLOT SIZE          MAIN0840
    WRITE(5,180) SAMMTD                       MAIN0850
180 FORMAT('OENTER ',A9)                     MAIN0860
    READ(5,*) BAF                             MAIN0870
C ASK USER IF HEIGHTS ARE IN LOGS           MAIN0880
190 WRITE(5,200)                             MAIN0890
200 FORMAT('OARE HEIGHTS IN FEET OR SIXTEEN FT. LOGS?'/
1' TYPE FEET OR LOGS')
    READ(5,210) LOGANS                        MAIN0900
210 FORMAT(A4)                               MAIN0910
    IF (LOGANS.NE.'FEET'.AND.LOGANS.NE.'LOGS') GOTO 190 MAIN0920
C ASK USER IF HEIGHTS ARE MERCHANTABLE OR TOTAL MAIN0930
220 WRITE(5,230)                             MAIN0940
230 FORMAT('OARE HEIGHTS TOTAL OR MERCHANTABLE?'/
1' TYPE TOTAL, MERCH, OR MIXED')
    READ(5,240) TOPANS                       MAIN0950
240 FORMAT(A5)                               MAIN0960
    IF (LOGANS.EQ.'FEET') MULT=1             MAIN0970
    IF (LOGANS.EQ.'LOGS') MULT=16            MAIN0980
    IF (TOPANS.NE.'TOTAL'.AND.TOPANS.NE.'MERCH'.AND.TOPANS.NE.'MIXED')
1 GOTO 220 MAIN0990
C ASK USER IF REGRESSION ROUTINE IS NEEDED MAIN1000
250 WRITE(5,260)                             MAIN1010
260 FORMAT('OWHERE THE HEIGHTS OF ALL VOLUME TREES MEASURED?')
    READ(5,270) REGANS                       MAIN1020
270 FORMAT(A3)                               MAIN1030
    IF (REGANS.NE.'YES'.AND.REGANS.NE.'NO') GOTO 250 MAIN1040
C ASK USER FOR ACREAGE                      MAIN1050
280 WRITE(5,290)                             MAIN1060
290 FORMAT('OENTER ACREAGE OF TRACT. ')
    READ(5,*) ACRES                          MAIN1070
C
C ***** MAIN1080
C IF NEEDED RUN THE HEIGHT REGRESSION ROUTINE MAIN1090
C ***** MAIN1100
C
    IF (REGANS.EQ.'NO') CALL LINREG(IFILE,TOPANS) MAIN1110
C
C ***** MAIN1120
C READ IN TREE DATA AND PROCESS            MAIN1130
C ***** MAIN1140
300 CALL GUTS                                MAIN1150
C
C ***** MAIN1160
C CALL THE OUTPUT ROUTINE                  MAIN1170
C ***** MAIN1180
C
    CALL OUTP1                                MAIN1190
C
C ***** MAIN1200
C ACCUMULATE TOTALS FROM EACH STRATA      MAIN1210
C ***** MAIN1220
C
    IF (ISTRAT.GT.1) CALL STRAT(ACRES,CLASIZ) MAIN1230
C
310 CONTINUE                                MAIN1240
C
C-----END PROGRAM CONTROL LOOP-----
C
C ***** MAIN1250
C CALCULATE COMBINED STRATA STATISTICS    MAIN1260
C ***** MAIN1270
C
    IF (ISTRAT.GT.1) CALL STRAT2              MAIN1280
C
C ***** MAIN1290
C OUTPUT STRATA COMBINED TOTALS          MAIN1300
C ***** MAIN1310
C
    IF (ISTRAT.GT.1) CALL OUTP2              MAIN1320
C
END                                           MAIN1330

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C SUBROUTINE FRMCLS FRMC0010
C FRMC0020
C FRMC0030
C*****FRMC0040
C FRMC0050
C THIS SUBPROGRAM READS IN AN ARRAY OF FORM CLASSES FROM A FRMC0060
C USER SPECIFIED DISK FILE. THIS DISK FILE IS FREE FOMMATED FRMC0070
C USING LIST DIRECTED INPUT. THE USER IS GIVEN THE OPTION FRMC0080
C TO LIST THE FORM CLASSES APFTER THEY ARE READ. FRMC0090
C FRMC0100
C*****FRMC0110
C FRMC0120
C INTEGER FC(32),SPECIE(32) FRMC0130
C DOUBLE PRECISION PCFILE FRMC0140
C REAL REGCOF(33),REGINT(33),SEREG(35),RSQR(33),MEANY(35) FRMC0150
C INTEGER MINDBH(32),NTR(35),TOTNTR(35) FRMC0160
C COMMON/REG/REGCOF,REGINT,SPECIE,MINDBH,SEREG,NTR,RSQR,MEANY FRMC0170
C 1,TOTNTR FRMC0180
C COMMON/FORMCL/PC FRMC0190
C HAVE USER SPECIFY FORM CLASS FILE NAME FRMC0200
C WRITE(5,10) FRMC0210
C 10 FORMAT('0ENTER FORM CLASS FILE NAME') FRMC0220
C READ FORM CLASSES FROM FILE FRMC0230
C READ(5,20) PCFILE FRMC0240
C 20 FORMAT(A10) FRMC0250
C OPEN(FILE=PCFILE,ACCESS='SEQIN',UNIT=1) FRMC0260
C READ(1,30) FC FRMC0270
C 30 FORMAT(8(I2,X)) FRMC0280
C ASK USER IF HE WANTS TO LIST FORM CLASSES JUST READ FRMC0290
C 40 WRITE(5,50) FRMC0300
C 50 FORMAT('0DO YOU WANT A LIST OF THE FORM CLASSES JUST READ?') FRMC0310
C READ(5,60) LSTANS FRMC0320
C 60 FORMAT(A3) FRMC0330
C IF (LSTANS.NE.'YES'.AND.LSTANS.NE.'NO') GOTO 40 FRMC0340
C IF (LSTANS.EQ.'NO') RETURN FRMC0350
C WRITE(5,70) (SPECIE(I),FC(I),I=1,32) FRMC0360
C 70 FORMAT('0',8('/', ' ',4(A2,' ',I2,5X)) FRMC0370
C RETURN FRMC0380
C END FRMC0390
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C                               LNRG0010
SUBROUTINE LINREG (IFILE, TOPANS)                               LNRG0020
C                               LNRG0030
C*****                               LNRG0040
C                               LNRG0050
C THIS SUBPROGRAM READS IN DATA FROM ALL THE SAMPLE TREES    LNRG0060
C IT FINDS THE TREES WITH HEIGHT MEASUREMENTS                  LNRG0070
C IT THEN FITS A REGRESSION MODEL FOR EACH SPECIE SAMPLED      LNRG0080
C                               LNRG0090
C MODEL: HEIGHT = B0 + B1 * 1/DBH                               LNRG0100
C                               LNRG0110
C*****                               LNRG0120
DOUBLE PRECISION IFILE                                         LNRG0130
REAL SEREG(35), RSQR(33), MSE, TYPSSSE(3)                       LNRG0140
REAL VARK(33), VARY(33), COVXY(33), REGCOF(33), REGINT(33)     LNRG0150
REAL X(33), Y(33), XSUM(33), YSUM(35), XSUMSQ(33), YSUMSQ(33)  LNRG0160
REAL XYSUM(33), MEANX(33), MEANY(35), HEIGHT, MNYCOR(3)        LNRG0170
INTEGER SPECIE(32), NTR(35), POINT, TREES, DBH, SPEC, MINDBH(32) LNRG0180
INTEGER TOTNTR(35), NUMREG(3), NTRCOR(3), TOPANS               LNRG0190
COMMON/REG/REGCOF, REGINT, SPECIE, MINDBH, SEREG, NTR, RSQR, MEANY
1, TOTNTR                                                       LNRG0200
C SET MINIMUM DBH'S TO 8                                         LNRG0220
DO 10 ISPEC=1,32                                               LNRG0230
10 MINDBH(ISPEC)=8                                             LNRG0240
C                               LNRG0250
C ZERO ALL ACCUMULATORS                                         LNRG0260
C                               LNRG0270
DO 20 JTYPE=1,3                                               LNRG0280
NTRCOR(JTYPE)=0                                               LNRG0290
MNYCOR(JTYPE)=0                                               LNRG0300
NUMREG(JTYPE)=0                                               LNRG0310
20 TYPSSSE(JTYPE)=0                                           LNRG0320
DO 30 ISPEC=1,35                                               LNRG0330
NTR(ISPEC)=0; YSUM(ISPEC)=0                                   LNRG0340
SEREG(ISPEC)=0; MEANY(ISPEC)=0                               LNRG0350
IF (ISPEC.GT.32) GOTO 30                                       LNRG0360
YSUM(ISPEC)=0; XSUMSQ(ISPEC)=0                                LNRG0370
YSUMSQ(ISPEC)=0; XYSUM(ISPEC)=0                               LNRG0380
REGCOF(ISPEC)=0; REGINT(ISPEC)=0; RSQR(ISPEC)=0              LNRG0390
30 CONTINUE                                                    LNRG0400
C                               LNRG0410
C INPUT POINT INFORMATION                                         LNRG0420
C                               LNRG0430
40 READ(21,50,END=130) POINT,TREES                             LNRG0440
50 FORMAT(I2,X,I2)                                             LNRG0450
C CHECK TO SEE IF DATA IS IN SUMMARY FORM                       LNRG0460
IF (POINT.NE.-9) GOTO 60                                       LNRG0470
TREES=1000000                                                 LNRG0480
C INPUT INDIVIDUAL TREE DATA                                   LNRG0490
60 LOOP=0                                                       LNRG0500
70 IF (LOOP.GE.TREES) GOTO 40                                   LNRG0510
READ(21,80,END=40) SPEC,DBH,HEIGHT,IREP                       LNRG0520
80 FORMAT(A2,X,I2,1X,F3.0,I2)                                  LNRG0530
IF (IREP.EQ.0) IREP=1                                          LNRG0540
LOOP=LOOP+IREP                                                 LNRG0550
C CHECK TO SEE IF TREE IS A CULL                                LNRG0560
IF (HEIGHT.EQ.999) GOTO 70                                     LNRG0570
C CHECK DBH                                                      LNRG0580
IF (DBH.LT.1) DBH=1                                           LNRG0590
IF (DBH.GT.40) DBH=40                                          LNRG0600
C CHECK HEIGHT                                                  LNRG0610
IF (HEIGHT.LT.0.) HEIGHT=0.                                    LNRG0620
IF (TOPANS.EQ.'FEET'.AND.HEIGHT.GT.200.) HEIGHT=200.         LNRG0630
IF (TOPANS.EQ.'LOGS'.AND.HEIGHT.GT.7.) HEIGHT=7.              LNRG0640
C CHECK TO SEE IF HEIGHT OF THIS TREE WAS MEASURED             LNRG0650
IF (HEIGHT.EQ.0) GOTO 70                                       LNRG0660
C DECODE SPECIE CODES                                           LNRG0670
DO 90 ISPEC=1,32                                               LNRG0680
90 IF (SPEC.EQ.SPECIE(ISPEC)) GOTO 110                         LNRG0690
C PRINT ERROR MESSAGE                                           LNRG0700
WRITE(5,100) SPEC,POINT                                         LNRG0710
100 FORMAT('0***ERROR*** ILLEGAL SPECIE CODE: ',A2,' AT POINT: ',I2,
1/'0DATA FOR THIS TREE IGNORED! EXECUTION CONTINUES.')
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LNRG0720
LNRG0730
LNRG0740
LNRG0750
LNRG0760
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C COMPUTE ACCUMULATED SUMS FOR INDIVIDUAL SPECIE
ITYPE=33
IF (ISPEC.GE.12) ITYPE=34
DO 120 IDUNMY=1,IREF
X (ISPEC) = 1.0/DBH
Y (ISPEC) =HEIGHT
NTR (ISPEC)=NTR (ISPEC) +1
NTR (ITYPE)=NTR (ITYPE)+1
NTR ( 35 )=NTR ( 35 ) +1
XSUM (ISPEC) =XSUM (ISPEC) +X (ISPEC)
YSUM (ISPEC) =YSUM (ISPEC) +Y (ISPEC)
YSUM (ITYPE) =YSUM (ITYPE) +Y (ISPEC)
YSUM ( 35 ) =YSUM ( 35 ) +Y (ISPEC)
XSUMSQ (ISPEC) =XSUMSQ (ISPEC) +X (ISPEC) **2
YSUMSQ (ISPEC) =YSUMSQ (ISPEC) +Y (ISPEC) **2
XYSUM (ISPEC) =XYSUM (ISPEC) +X (ISPEC) *Y (ISPEC)
120 CONTINUE
GOTO 70
130 CONTINUE
C
C COMPUTE REGRESSION PARAMETERS FOR ALL SPECIES
DO 170 ISPEC=1,32
JTYPE=1
IF (ISPEC.GE.12) JTYPE=2
IF (NTR (ISPEC) .LT. 1) GOTO 170
MEANY (ISPEC) =YSUM (ISPEC) /NTR (ISPEC)
C CHECK TO SEE IF ENOUGH TREES EXIST FOR REGRESSION
IF (NTR (ISPEC) .GE. 3) GOTO 140
C CALCULATE CORRECTION SUMS FOR SPECIES WHERE NO REGRESSION WAS RUN
MNYCOR (JTYPE) =MNYCOR (JTYPE) +YSUM (ISPEC)
NTRCOR (JTYPE) =NTRCOR (JTYPE) +NTR (ISPEC)
GOTO 170
140 NUMREG (JTYPE) =NUMREG (JTYPE) +1
MEANX (ISPEC) =XSUM (ISPEC) /NTR (ISPEC)
VARX (ISPEC) = (XSUMSQ (ISPEC) -
1 (XSUM (ISPEC) **2/NTR (ISPEC) ) ) / (NTR (ISPEC) -1)
VARY (ISPEC) = (YSUMSQ (ISPEC) -
1 (YSUM (ISPEC) **2/NTR (ISPEC) ) ) / (NTR (ISPEC) -1)
COVXY (ISPEC) = (XYSUM (ISPEC) -
1 XSUM (ISPEC) *YSUM (ISPEC) /NTR (ISPEC) ) / (NTR (ISPEC) -1)
C CHECK TO SEE IF VARIANCE IS ZERO
IF (VARX (ISPEC) .GT. 0.000001 .AND. VARY (ISPEC) .GT. 0.000001)
1 GOTO 150
REGINT (ISPEC) =MEANX (ISPEC)
GOTO 160
150 REGCOF (ISPEC) =COVXY (ISPEC) /VARX (ISPEC)
REGINT (ISPEC) =MEANX (ISPEC) -REGCOF (ISPEC) *MEANX (ISPEC)
160 IF (VARY (ISPEC) .LT. 0.0000001) GOTO 170
SSE =YSUMSQ (ISPEC) -REGINT (ISPEC) *YSUM (ISPEC) -
1 REGCOF (ISPEC) *XYSUM (ISPEC)
TYPSSSE (JTYPE) =TYPSSSE (JTYPE) +SSE
MSE =SSE / (NTR (ISPEC) -2)
SEREG (ISPEC) =SQRT (MSE/NTR (ISPEC) ) *100/MEANX (ISPEC)
RSQR (ISPEC) =100*(COVXY (ISPEC) **2) / (VARX (ISPEC) *VARY (ISPEC) )
170 CONTINUE
C
C COMPUTE STANDARD ERROR FOR SOFTWOOD,HARDWOOD, ALL SPECIES
C
NTRCOR (3) =NTRCOR (1) +NTRCOR (2)
MNYCOR (3) =MNYCOR (1) +MNYCOR (2)
TYPSSSE (3) =TYPSSSE (1) +TYPSSSE (2)
NUMREG (3) =NUMREG (1) +NUMREG (2)
DO 180 JTYPE=1,3
ISPEC=JTYPE+32
IF (NTR (ISPEC) .LE. 0) GOTO 180
MEANY (ISPEC) =YSUM (ISPEC) /NTR (ISPEC)
CORNTR =NTR (ISPEC) -NTRCOR (JTYPE)
IF (CORNTR .LE. 0) GOTO 180
CORMNY = (YSUM (ISPEC) -MNYCOR (JTYPE) ) /CORNTR
MSE =TYPSSSE (JTYPE) / (CORNTR -2*NUMREG (JTYPE) )
SEREG (ISPEC) =SQRT (MSE/CORNTR) *100/CORMNY
180 CONTINUE
CLOSE (UNIT=21)
OPEN (UNIT=21, ACCESS='SEQIN', FILE=IFILE)
SKIP RECORD 21
RETURN
END

```



```
C CHECK DBH TO SEE IF WITHIN LEGAL LIMITS          GUTS0790
  90 IF (DBH.LT.CLASIZ) DBH=CLASIZ                 GUTS0800
    IF (DBH.GT.40) DBH=40                          GUTS0810
C TALLY TREES FOR EACH SPECIES                      GUTS0820
  ISPEC=I                                           GUTS0830
  TRECNT(DBH,ISPEC)=TRECNT(DBH,ISPEC) +IREP       GUTS0840
C CHECK TO SEE IF DIAMETER IS ABOVE MINIMUM LIMIT  GUTS0850
  IF (DBH.LT.MINDBH(ISPEC).AND.REGANS.EQ.'NO') GOTO 50 GUTS0860
C ACCUMULATE NUMBER OF NON-CULL TREES ABOVE MIN DBH SAMPLED GUTS0870
  TOTNTR(ISPEC)=TOTNTR(ISPEC)+IREP                GUTS0880
  IF (ISPEC.LE.11) TOTNTR(33)=TOTNTR(33)+IREP    GUTS0890
  IF (ISPEC.GE.12) TOTNTR(34)=TOTNTR(34)+IREP    GUTS0900
  TOTNTR(35)=TOTNTR(35)+IREP                     GUTS0910
C IF HEIGHT WAS NOT MEASURED GENERATE HEIGHT FROM REGRESSION GUTS0920
  IF (HEIGHT.EQ.0.AND.REGANS.EQ.'NO') HEIGHT=REGINT(I)+REGCOF(I)/DBH GUTS0930
  IF (HEIGHT.EQ.0) GOTO 50                         GUTS0940
C COMPUTE VOLUMES                                  GUTS0950
C CHECK TO SEE IF TREE A CULL                      GUTS0960
  IF (HEIGHT.EQ.999) GOTO 50                       GUTS0970
  HEIGHT=HEIGHT*MULT                               GUTS0980
C CHECK HEIGHT TO SEE IF WITHIN LEGAL LIMITS       GUTS0990
  IF (HEIGHT.LT.0) HEIGHT=0                       GUTS1000
  IF (MULT.EQ.1.AND.HEIGHT.GT.200) HEIGHT=200.    GUTS1010
  IF (MULT.EQ.16.AND.HEIGHT.GT.128) HEIGHT=128    GUTS1020
  IF (TOPANS.EQ.'TOTAL') CALL VOLTOT(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL) GUTS1030
  IF (TOPANS.EQ.'MERCH') CALL VOLMER(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL) GUTS1040
  IF (TOPANS.EQ.'MIXED'.AND.ISPEC.GT.11)          CALL VOLMER(DBH,HEIGHT, GUTS1050
  1ISPEC,CUBVOL,BDVOL)                            GUTS1060
  IF (TOPANS.EQ.'MIXED'.AND.ISPEC.LE.11)          CALL VOLTOT(DBH,HEIGHT, GUTS1070
  1ISPEC,CUBVOL,BDVOL)                            GUTS1080
  PULVOL=0                                         GUTS1090
C CHECK TO SEE IF % SAWLOG OPTION USED             GUTS1100
  IF (PROD.NE.'%') GOTO 100                       GUTS1110
C CHECK PCTSAW TO SEE IF WITHIN LEGAL LIMITS       GUTS1120
  IF (PCTSAW.LT.0) PCTSAW=0.0                     GUTS1130
  IF (PCTSAW.GT.1.0) PCTSAW=1.0                   GUTS1140
  BDVOL =PCTSAW*BDVOL                             GUTS1150
  PULVOL=(1.-PCTSAW)*CUBVOL                       GUTS1160
  CUBVOL=PCTSAW*CUBVOL                            GUTS1170
  GOTO 110                                         GUTS1180
C CHECK TO SEE IF TREE IS PULPWOOD                GUTS1190
  100 IF (PROD.NE.'P') GOTO 110                   GUTS1200
  PULVOL=CUBVOL;CUBVOL=0;BDVOL=0                  GUTS1210
  110 CBVLSM(DBH,ISPEC)=CBVLSM(DBH,ISPEC)+CUBVOL*IREP GUTS1220
  BDVLSM(DBH,ISPEC)=BDVLSM(DBH,ISPEC)+BDVOL*IREP GUTS1230
  PLVLSM(DBH,ISPEC)=PLVLSM(DBH,ISPEC)+PULVOL*IREP GUTS1240
C                                                                 GUTS1250
C ACCUMULATE SUMS FOR VOLUME STANDARD ERRORS      GUTS1260
C                                                                 GUTS1270
C CHECK TO SEE IF DATA IS IN SUMMARY FORM        GUTS1280
  IF (POINT.EQ.-9) GOTO 50                         GUTS1290
C                                                                 GUTS1300
  IF (FRAME.EQ.'PLOT') FACTOR=1.0/BAF             GUTS1310
  IF (FRAME.EQ.'POINT') FACTOR=BAF/(.005454*DBH**2) GUTS1320
  CUBPT (ISPEC)=CUBPT (ISPEC) +CUBVOL*IREP*FACTOR GUTS1330
  BRDPT (ISPEC)=BRDPT (ISPEC) +BDVOL*IREP*FACTOR GUTS1340
  PULPT (ISPEC)=PULPT (ISPEC) +PULVOL*IREP*FACTOR GUTS1350
  IF (ISPEC.LE.11) ITYPE=33                       GUTS1360
  IF (ISPEC.GT.11) ITYPE=34                       GUTS1370
  CUBPT (ITYPE)=CUBPT (ITYPE) +CUBVOL*IREP*FACTOR GUTS1380
  BRDPT (ITYPE)=BRDPT (ITYPE) +BDVOL*IREP*FACTOR GUTS1390
  PULPT (ITYPE)=PULPT (ITYPE) +PULVOL*IREP*FACTOR GUTS1400
  CUBPT (35)=CUBPT (35) +CUBVOL*IREP*FACTOR      GUTS1410
  BRDPT (35)=BRDPT (35) +BDVOL*IREP*FACTOR      GUTS1420
  PULPT (35)=PULPT (35) +PULVOL*IREP*FACTOR      GUTS1430
C                                                                 GUTS1440
  GOTO 50                                           GUTS1450
  120 CONTINUE                                     GUTS1460
C IF IN SUMMARY MODE DON'T ACCUMULATE VOLUMES OR INCREMENT NPNTS GUTS1470
  IF (POINT.EQ.-9) GOTO 140                       GUTS1480
C TALLY NUMBER OF POINTS SAMPLED                  GUTS1490
  NPNTS=NPNTS+1                                    GUTS1500
```



```
C ACCUMULATE SUMS OF SQUARES FOR VOLUMES
DO 130 ISPEC=1,35
  CUBSQ (ISPEC) =CUBSQ (ISPEC) +CUBPT (ISPEC) **2
  BRDSQ (ISPEC) =BRDSQ (ISPEC) +BRDPT (ISPEC) **2
  PULSQ (ISPEC) =PULSQ (ISPEC) +PULPT (ISPEC) **2
  CUBPT (ISPEC) =0
  PULPT (ISPEC) =0
130 BRDPT (ISPEC) =0
  GOTO 20
140 CONTINUE
C IF ONLY ONE POINT SAMPLED, SET IN SUMMARY MODE
  IF (NPNTS.EQ.1) POINT=-9
C
C *****
C DETERMINE SAMPLING METHOD
C *****
C
  IF (FRAME.EQ.'PLOT') GOTO 170
C
C *****
C POINT SAMPLING
C
C CALCULATE PER ACRE ESTIMATES FOR INDIVIDUAL SPECIES
C *****
C
  DO 160 ISPEC=1,32
  DO 150 DBH=CLASIZ,40,CLASIZ
C CHECK TO SEE IF ANY TREES TALLIED
  IF (TRECNT (DBH, ISPEC) .EQ.0) GOTO 150
C BASAL AREA CALCULATIONS
  BASPAC (DBH, ISPEC) =TRECNT (DBH, ISPEC) *BAF/NPNTS
  BASTOT (ISPEC) =BASTOT (ISPEC) +BASPAC (DBH, ISPEC)
C TREES PER ACRE CALCULATIONS
  TREPAC (DBH, ISPEC) =BASPAC (DBH, ISPEC) /(.005454*DBH**2)
  TRETOT (ISPEC) =TRETOT (ISPEC) +TREPAC (DBH, ISPEC)
C CUBIC VOLUME CALCULATIONS
  CBVLSM (DBH, ISPEC) =CBVLSM (DBH, ISPEC) *BAF /
  (NPNTS*.005454*DBH**2)
  CBTOT (ISPEC) =CBTOT (ISPEC) +CBVLSM (DBH, ISPEC)
C BOARD FOOT VOLUME CALCULATIONS
  BDVLSM (DBH, ISPEC) =BDVLSM (DBH, ISPEC) *BAF /
  (NPNTS*.005454*DBH**2)
  BDTOT (ISPEC) =BDTOT (ISPEC) +BDVLSM (DBH, ISPEC)
C PULPWOOD CALCULATIONS
  PLVLSM (DBH, ISPEC) =PLVLSM (DBH, ISPEC) *BAF /
  (NPNTS*.005454*DBH**2)
  PLTOT (ISPEC) =PLTOT (ISPEC) +PLVLSM (DBH, ISPEC)
150 CONTINUE
160 CONTINUE
  GOTO 200
C
C *****
C PLOT SAMPLING
C
C CALCULATE PER ACRE ESTIMATES FOR INDIVIDUAL SPECIES
C *****
C
  170 PLTSIZ=BAF
  NPLOTS=NPNTS
  DO 190 ISPEC=1,32
  DO 180 DBH=CLASIZ,40,CLASIZ
C CHECK TO SEE IF ANY TREES TALLIED
  IF (TRECNT (DBH, ISPEC) .EQ.0) GOTO 180
C TREES PER ACRE CALCULATIONS
  TREPAC (DBH, ISPEC) =TRECNT (DBH, ISPEC) /PLTSIZ/NPLOTS
  TRETOT (ISPEC) =TRETOT (ISPEC) +TREPAC (DBH, ISPEC)
C BASAL AREA CALCULATIONS
  BASPAC (DBH, ISPEC) =TREPAC (DBH, ISPEC) *.005454*DBH**2
  BASTOT (ISPEC) =BASTOT (ISPEC) +BASPAC (DBH, ISPEC)
C CUBIC VOLUME CALCULATIONS
  CBVLSM (DBH, ISPEC) =CBVLSM (DBH, ISPEC) /PLTSIZ/NPLOTS
  CBTOT (ISPEC) =CBTOT (ISPEC) +CBVLSM (DBH, ISPEC)
C BOARD FOOT VOLUME CALCULATIONS
  BDVLSM (DBH, ISPEC) =BDVLSM (DBH, ISPEC) /PLTSIZ/NPLOTS
  BDTOT (ISPEC) =BDTOT (ISPEC) +BDVLSM (DBH, ISPEC)
C PULPWOOD CALCULATIONS
  PLVLSM (DBH, ISPEC) =PLVLSM (DBH, ISPEC) /PLTSIZ/NPLOTS
  PLTOT (ISPEC) =PLTOT (ISPEC) +PLVLSM (DBH, ISPEC)
180 CONTINUE
190 CONTINUE
```

GUTS1510  
GUTS1520  
GUTS1530  
GUTS1540  
GUTS1550  
GUTS1560  
GUTS1570  
GUTS1580  
GUTS1590  
GUTS1600  
GUTS1610  
GUTS1620  
GUTS1630  
GUTS1640  
GUTS1650  
GUTS1660  
GUTS1670  
GUTS1680  
GUTS1690  
GUTS1700  
GUTS1710  
GUTS1720  
GUTS1730  
GUTS1740  
GUTS1750  
GUTS1760  
GUTS1770  
GUTS1780  
GUTS1790  
GUTS1800  
GUTS1810  
GUTS1820  
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GUTS1880  
GUTS1890  
GUTS1900  
GUTS1910  
GUTS1920  
GUTS1930  
GUTS1940  
GUTS1950  
GUTS1960  
GUTS1970  
GUTS1980  
GUTS1990  
GUTS2000  
GUTS2010  
GUTS2020  
GUTS2030  
GUTS2040  
GUTS2050  
GUTS2060  
GUTS2070  
GUTS2080  
GUTS2090  
GUTS2100  
GUTS2110  
GUTS2120  
GUTS2130  
GUTS2140  
GUTS2150  
GUTS2160  
GUTS2170  
GUTS2180  
GUTS2190  
GUTS2200  
GUTS2210  
GUTS2220  
GUTS2230  
GUTS2240  
GUTS2250  
GUTS2260  
GUTS2270  
GUTS2280  
GUTS2290  
GUTS2300

```
C
C *****
C CALCULATE TOTALS FOR SOFTWOODS AND HARDWOODS
C *****
C
200 DO 230 ITYPE=33,34
    DO 220 DBH=CLASIZ,40,CLASIZ
        DO 210 ISPEC=ISTART (ITYPE-32) , ISTOP (ITYPE-32)
            BASPAC (DBH, ITYPE) =BASPAC (DBH, ITYPE) +BASPAC (DBH, ISPEC)
            TREPAC (DBH, ITYPE) =TREPAC (DBH, ITYPE) +TREPAC (DBH, ISPEC)
            CBVLSM (DBH, ITYPE) =CBVLSM (DBH, ITYPE) +CBVLSM (DBH, ISPEC)
            BDVLSM (DBH, ITYPE) =BDVLSM (DBH, ITYPE) +BDVLSM (DBH, ISPEC)
        210
            PLVLSM (DBH, ITYPE) =PLVLSM (DBH, ITYPE) +PLVLSM (DBH, ISPEC)
            BASTOT (ITYPE) =BASTOT (ITYPE) +BASPAC (DBH, ITYPE)
            TRETOT (ITYPE) =TRETOT (ITYPE) +TREPAC (DBH, ITYPE)
            CBTOT (ITYPE) =CBTOT (ITYPE) +CBVLSM (DBH, ITYPE)
            BDTOT (ITYPE) =BDTOT (ITYPE) +BDVLSM (DBH, ITYPE)
        220
            PLTOT (ITYPE) =PLTOT (ITYPE) +PLVLSM (DBH, ITYPE)
        230 CONTINUE
C
C *****
C CALCULATE TOTALS FOR ALL SPECIES
C *****
C
    DO 240 DBH=CLASIZ,40,CLASIZ
        BASPAC (DBH,35) =BASPAC (DBH,33) +BASPAC (DBH,34)
        TREPAC (DBH,35) =TREPAC (DBH,33) +TREPAC (DBH,34)
        CBVLSM (DBH,35) =CBVLSM (DBH,33) +CBVLSM (DBH,34)
        BDVLSM (DBH,35) =BDVLSM (DBH,33) +BDVLSM (DBH,34)
        PLVLSM (DBH,35) =PLVLSM (DBH,33) +PLVLSM (DBH,34)
    240 CONTINUE
        BASTOT (35) =BASTOT (33) +BASTOT (34)
        TRETOT (35) =TRETOT (33) +TRETOT (34)
        CBTOT (35) =CBTOT (33) +CBTOT (34)
        BDTOT (35) =BDTOT (33) +BDTOT (34)
        PLTOT (35) =PLTOT (33) +PLTOT (34)
C
C *****
C CALCULATE STANDARD ERRORS
C *****
C
    FINPOP=1.0
    IF (FRAME.EQ.'PLOT') FINPOP=((ACRES/BAF)-NPNTS)/(ACRES/BAF)
    IF (FINPOP.LT.0.0) FINPOP=0.0
C CHECK TO SEE IF DATA IS IN SUMMARY FORM
    IF (POINT.EQ.-9) GOTO 270
    DO 260 ISPEC=1,35
        IF (TRETOT (ISPEC).EQ.0) GOTO 260
        IF (FRAME.EQ.'PLOT') GOTO 250
        PCTCRZ=100*NPNTS*BASTOT (ISPEC) /TRETOT (ISPEC) /ACRES/EAF
        IF (PCTCRZ.GT.100.0) PCTCRZ=100.0
        FINPOP=(100-PCTCRZ) /100
    250
        VARCUB=(CUBSQ (ISPEC) -NPNTS*(CBTOT (ISPEC)**2))/(NPNTS-1)
        VARBRD=(BRDSQ (ISPEC) -NPNTS*(BDTOT (ISPEC)**2))/(NPNTS-1)
        VARPUL=(PULSQ (ISPEC) -NPNTS*(PLTOT (ISPEC)**2))/(NPNTS-1)
        SECUB (ISPEC) =SQRT ((VARCUB/NPNTS) *FINPOP)
        SEBRD (ISPEC) =SQRT ((VARBRD (ISPEC) /NPNTS) *FINPOP)
        SEPUL (ISPEC) =SQRT ((VARPUL (ISPEC) /NPNTS) *FINPOP)
C CHECK TO SEE IF REGRESSION ROUTINE USED
    260 IF (REGANS.EQ.'YES') RETURN
    DO 280 ISPEC=1,35
        IF (TOTNTR (ISPEC).EQ.0) GOTO 280
        REGWGT=FLOAT (TOTNTR (ISPEC) -NTR (ISPEC) ) /FLOAT (TOTNTR (ISPEC) )
        SECUB (ISPEC) =SQRT (SECUB (ISPEC) **2 +
        1 REGWGT*(SEREG (ISPEC) *CBTOT (ISPEC) /100.) **2)
        SEBRD (ISPEC) =SQRT (SEBRD (ISPEC) **2 +
        1 REGWGT*(SEREG (ISPEC) *BDTOT (ISPEC) /100.) **2)
        SEPUL (ISPEC) =SQRT (SEPUL (ISPEC) **2 +
        1 REGWGT*(SEREG (ISPEC) *PLTOT (ISPEC) /100.) **2)
    280 CONTINUE
    RETURN
    END
GUTS2310
GUTS2320
GUTS2330
GUTS2340
GUTS2350
GUTS2360
GUTS2370
GUTS2380
GUTS2390
GUTS2400
GUTS2410
GUTS2420
GUTS2430
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GUTS2450
GUTS2460
GUTS2470
GUTS2480
GUTS2490
GUTS2500
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GUTS2800
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GUTS2890
GUTS2900
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GUTS2950
GUTS2960
GUTS2970
GUTS2980
GUTS2990
GUTS3000
GUTS3010
GUTS3020
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```
C
SUBROUTINE VOLMER (DBH, HEIGHT, ISPEC, CUBVOL, BDVOL)
C
C*****
C THIS SUBPROGRAM COMPUTES THE MERCHANTABLE CUBIC AND BOARD FOOT
C VOLUMES OF INDIVIDUAL TREES. THE INPUT PARAMETERS ARE DBH,
C MERCHANTABLE HEIGHT, AND SPECIES.
C
C THE CUBIC FOOT EQUATIONS ARE FROM BARNARD, JOSEPH E. ET AL. 1973.
C FOREST SURVEY CUBIC-FOOT VOLUME EQUATIONS. USDA FOREST SERV.
C NE. FOREST EXP. STA. RESEARCH NOTE NE-66.
C
C THE BOARD FOOT EQUATIONS ARE FROM WIAANT, H.V. AND CASTENADA, P. 1977
C MESAVAGE AND GIRARD'S VOLUME TABLES FORMULATED. RESOURCE INVENTORY
C NOTES, USDI, BLM, DENVER, COLO.
C*****
C
C REAL HEIGHT, CUBINT (17), CUBSLP (17), BDHT
C INTEGER DBH, GRP (32), D, FC (32)
C COMMON/FORMCL/FC
C
C DEFINE FORM CLASS FOR THE SPECIES
C
C DATA (FC(I), I=1, 32) /3*76, 70, 7*76, 21*74/
C
C DEFINE VOLUME EQUATION GROUPING FOR THE SPECIES
C
C DATA (GRP(I), I=1, 32) /1, 1, 5, 4, 3, 5, 2, 5, 5, 6, 1, 7, 8, 9, 17, 9, 8, 10
C 1, 4*11, 12, 13, 14, 15, 14, 15, 14, 16, 2*17/
C
C DEFINE THE INTERCEPTS FOR THE CUBIC VOLUME EQUATIONS
C
C DATA (CUBINT(I), I=1, 17) /3.5142, 2.1998, 1.4793, 2.4784, -.0496, 1.5817
C 1, 1.6823, 1.1763, 1.0067, 1.1809, 1.1339, 1.2851, .8976, 1.2027, 1.0009
C 2, 1.4438, .8591/
C
C DEFINE THE SLOPES FOR THE CUBIC VOLUME EQUATIONS
C
C DATA (CUBSLP(I), I=1, 17) /236, 257, 272, 242, 303, 259, 310, 310, 293, 292
C 1, 281, 326, 349, 301, 300, 316, 309/
C
C FUNCTION TO COMPUTE BOARD FOOT VOLUMES FOR G. P. C. 78
C
C WIAANT (DBH, BDHT) = (-13.35212 + 9.58615 * BDHT + 1.52968 * BDHT**2) +
C 1 (1.79620 - 2.59995 * BDHT - .27465 * BDHT**2) * DBH +
C 2 (.04482 - .45997 * BDHT - .00961 * BDHT**2) * DBH**2
C
C DETERMINE BOARD FOOT HEIGHT TO THE HALF-LOG
C
C BDHT=HEIGHT/16.0
C CBHT=HEIGHT
C
C CALCULATE CUBIC AND BOARD FOOT VOLUME
C
C CUBVOL=CUBINT (GRP (ISPEC)) + .00001 * CUBSLP (GRP (ISPEC)) * CBHT * DBH**2
C BDVOL=WIAANT (DBH, BDHT) * ((FC (ISPEC) - 78) * .03) + 1
C IF (BDHT.LT.0.5) BDVOL=0
C IF (CUBVOL.LT.0) CUBVOL=0
C IF (BDVOL.LT.0) BDVOL=0
C RETURN
C END
```

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VLNR0010
VLNR0020
VLNR0030
VLNR0040
VLNR0050
VLNR0060
VLNR0070
VLNR0080
VLNR0090
VLNR0100
VLNR0110
VLNR0120
VLNR0130
VLNR0140
VLNR0150
VLNR0160
VLNR0170
VLNR0180
VLNR0190
VLNR0200
VLNR0210
VLNR0220
VLNR0230
VLNR0240
VLNR0250
VLNR0260
VLNR0270
VLNR0280
VLNR0290
VLNR0300
VLNR0310
VLNR0320
VLNR0330
VLNR0340
VLNR0350
VLNR0350
VLNR0370
VLNR0380
VLNR0390
VLNR0400
VLNR0410
VLNR0420
VLNR0430
VLNR0440
VLNR0450
VLNR0460
VLNR0470
VLNR0480
VLNR0490
VLNR0500
VLNR0510
VLNR0520
VLNR0530
VLNR0540
VLNR0550
VLNR0560
VLNR0570
VLNR0580
VLNR0590
VLNR0600
VLNR0610
VLNR0620
VLNR0630
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C SUBROUTINE VOLTOT (DBH,HEIGHT,ISPEC,CUBVOL,BDVOL) VLT0010
C VLT0020
C VLT0030
C ***** VLT0040
C VLT0050
C THIS SUBPROGRAM COMPUTES THE MERCHANTABLE CUBIC AND BOARD FOOT VOLUME
C VLT0060
C VOLUMES OF INDIVIDUAL TREES. THE INPUT PARAMETERS ARE DBH, VLT0070
C TOTAL HEIGHT, AND SPECIES. VLT0080
C VLT0090
C ALL OF THE EQUATIONS USED ARE FROM HONER, T.G. 1967. STANDARD VOLUME VLT0100
C TABLES AND MERCHANTABLE CONVERSION FACTORS FOR THE COMMERCIAL TREE VLT0110
C SPECIES OF CENTRAL AND EASTERN CANADA. PMR-X-5, PMI, OTTAWA, CANADA VLT0120
C VLT0130
C ***** VLT0140
C VLT0150
C INTEGER GRP(32),DBH VLT0160
C REAL CUBINT(16),CUBSLP(16),ASDRCF(3),ASDRBF(3),BRDTOP(2),CUBTOP(2) VLT0170
C VLT0180
C DEFINE VOLUME EQUATION GROUPING FOR THE TREE SPECIES VLT0190
C VLT0200
C DATA (GRP(I),I=1,32)/1,2,2,6,4,2,3,3,2,5,2,10,10,16,15,7,10,13 VLT0210
C 1,8,9,8,8,12,11,3*16,14,16,16,15,15/ VLT0220
C VLT0230
C DEFINE THE INTERCEPTS FOR THE TOTAL CUBIC FT VOL EQUATION VLT0240
C VLT0250
C DATA (CUBINT(I),I=1,16)/-.691,-.710,1.226,2.139,4.167,1.112,-.312 VLT0260
C 1,2.222,1.449,1.046,.948,.959,.033,-.634,1.877,1.512/ VLT0270
C VLT0280
C DEFINE THE SLOPES FOR THE TOTAL CUBIC FT VOL EQUATION VLT0290
C VLT0300
C DATA (CUBSLP(I),I=1,16)/363.676,355.623,315.832,301.634,244.906 VLT0310
C 1,350.092,436.683,300.373,344.754,383.972,401.456,334.829 VLT0320
C 2,393.366,440.496,332.585,336.509/ VLT0330
C VLT0340
C DEFINE STUMP HEIGHT AND MERCH TOPS VLT0350
C VLT0360
C DATA STUMP/0.5/ VLT0370
C DATA (CUBTOP(I),I=1,2)/4.0,4.0/ VLT0380
C DATA (BRDTOP(I),I=1,2)/6.0,8.0/ VLT0390
C VLT0400
C DEFINE ADJUSTED SQRD DIA RATIO CUBIC FT VOL CONVERSION COEFFICIENTS VLT0410
C VLT0420
C DATA (ASDRCF(I),I=1,3)/.9604,-.1660,-.7868/ VLT0430
C VLT0440
C DEFINE ADJUSTED SQRD DIA RATIO BOARD FT VOL CONVERSION COEFFICIENTS VLT0450
C VLT0460
C DATA (ASDRBF(I),I=1,3)/5.4332,-1.6281,-4.4710/ VLT0470
C VLT0480
C DETERMINE SW OR HW TYPE VLT0490
C VLT0500
C IF (ISPEC.LE.11) ITYPE=1 VLT0510
C IF (ISPEC.GE.12) ITYPE=2 VLT0520
C VLT0530
C COMPUTE TOTAL CUBIC FOOT VOLUME VLT0540
C VLT0550
C TCBVOL=DBB**2/(CUBINT(GRP(ISPEC))+CUBSLP(GRP(ISPEC))/HEIGHT) VLT0560
C VLT0570
C COMPUTE MERCH CUBIC AND BOARD FT VOLUMES VLT0580
C VLT0590
C XCUB=((CUBTOP(ITYPE)/DBH)**2)*(1.0+STUMP/HEIGHT) VLT0600
C XBRD=((BRDTOP(ITYPE)/DBH)**2)*(1.0+STUMP/HEIGHT) VLT0610
C CUBVOL=TCBVOL*(ASDRCF(1)+ASDRCF(2)*XCUB+ASDRCF(3)*XCUB**2) VLT0620
C BDVOL=TCBVOL*(ASDRBF(1)+ASDRBF(2)*XBRD+ASDRBF(3)*XBRD**2) VLT0630
C IF (CUBVOL.LT.0) CUBVOL=0 VLT0640
C IF (BDVOL.LT.0) BDVOL=0 VLT0650
C RETURN VLT0660
C END VLT0670

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C STRT0010
SUBROUTINE STRAT (ACRES,CLASIZ) STRT0020
C STRT0030
C***** STRT0040
C STRT0050
C THIS SUBPROGRAM CALCULATES COMBINED STRATA STATISTICS STRT0060
C STRT0070
C***** STRT0080
C STRT0090
INTEGER CLASIZ STRT0100
REAL STSECB (35),STSEBD (35),EPDFCB (35),EPDFBD (35) STRT0110
REAL STVMCB (35),STMVBD (35),DFCB2 (35),DFBD2 (35) STRT0120
REAL STVMPL (35),DFPL2 (35),PLTST (35),STSEPL (35),EPDFPL (35) STRT0130
REAL PLVLST (40,35) STRT0140
REAL CBTST (35),BDTST (35),CBVLST (40,35),BDVLST (40,35) STRT0150
COMMON/OUT1/BASPAC (40,35),BASTOT (35),BDTOT (35),BDVLSM (40,35), STRT0160
1CBTOT (35),CBVLSM (40,35),TREPAC (40,35),TRETOT (35) STRT0170
2,SECUB (35),SEBRD (35),NPNTS,PLVLSM (40,35),PLTOT (35),SEFUL (35) STRT0180
3,PINPOP,VARBRD (35),VARPUL (35) STRT0190
COMMON/STOUT/CBTST, BDTST, CBVLST, BDVLST, STSECB, STSEBD, EPDFCB STRT0200
1,EPDFBD, TACRES, PLTST, PLVLST, STSEPL, EPDFPL STRT0210
C ZERO ACCUMULATORS AND OTHER VARIABLES STRT0220
DATA ((CBVLST (J,I),BDVLST (J,I),PLVLST (J,I) , J=1,40,1) STRT0230
1,CBTST (I),BDTST (I),PLTST (I),STVMCB (I),STMVBD (I),STVMPL (I) STRT0240
2,DFCB2 (I),DFBD2 (I),DFPL2 (I),EPDFCB (I),EPDFBD (I),EPDFPL (I) STRT0250
3,STSECB (I),STSEBD (I),STSEPL (I) . I=1,35) / 4725*0.0 / STRT0260
C STRT0270
TACRES=TACRES+ACRES STRT0280
C STRT0290
C ACCUMULATE SUMS FOR VOLUMES STRT0300
C STRT0310
DO 20 ISPEC=1,35 STRT0320
DO 10 DBH=CLASIZ,40,CLASIZ STRT0330
CBVLST (DBH,ISPEC)=CBVLST (DBH,ISPEC)+CBVLSM (DBH,ISPEC)*ACRES STRT0340
BDVLST (DBH,ISPEC)=BDVLST (DBH,ISPEC)+BDVLSM (DBH,ISPEC)*ACRES STRT0350
10 PLVLST (DBH,ISPEC)=PLVLST (DBH,ISPEC)+PLVLSM (DBH,ISPEC)*ACRES STRT0360
CBTST (ISPEC)=CBTST (ISPEC)+CBTOT (ISPEC)*ACRES STRT0370
BDTST (ISPEC)=BDTST (ISPEC)+BDTOT (ISPEC)*ACRES STRT0380
PLTST (ISPEC)=PLTST (ISPEC)+PLTOT (ISPEC)*ACRES STRT0390
C STRT0400
C ACCUMULATE SUMS FOR VARIANCE AND D.F. STRT0410
C STRT0420
IF (NPNTS.LT.2) GOTO 20 STRT0430
STVMCB (ISPEC)=STVMCB (ISPEC)+(ACRES**2)*(SECUB (ISPEC)**2) STRT0440
STMVBD (ISPEC)=STMVBD (ISPEC)+(ACRES**2)*(SEBRD (ISPEC)**2) STRT0450
STVMPL (ISPEC)=STVMPL (ISPEC)+(ACRES**2)*(SEFUL (ISPEC)**2) STRT0460
DFCB2 (ISPEC)=DFCB2 (ISPEC)+ACRES**4*SECUB (ISPEC)**4/(NPNTS-1) STRT0470
DFBD2 (ISPEC)=DFBD2 (ISPEC)+ACRES**4*SEBRD (ISPEC)**4/(NPNTS-1) STRT0480
DFPL2 (ISPEC)=DFPL2 (ISPEC)+ACRES**4*SEFUL (ISPEC)**4/(NPNTS-1) STRT0490
20 CONTINUE STRT0500
RETURN STRT0510
C STRT0520
C***** STRT0530
C CALCULATE STANDARD ERRORS AND EFFECTIVE D.F. STRT0540
C BASED ON PREVIOUSLY ACCUMULATED SUMS STRT0550
C***** STRT0560
C STRT0570
ENTRY STRAT2 STRT0580
DO 50 ISPEC=1,35 STRT0590
IF (PLTST (ISPEC).EQ.0) GOTO 30 STRT0600
STSEPL (ISPEC)=SQRT (STVMPL (ISPEC)/TACRES**2) STRT0610
IF (DFPL2 (ISPEC).EQ.0) GOTO 30 STRT0620
EPDFPL (ISPEC)=STVMPL (ISPEC)**2/DFPL2 (ISPEC) STRT0630
30 IF (CBTST (ISPEC).EQ.0) GOTO 50 STRT0640
STSECB (ISPEC)=SQRT (STVMCB (ISPEC)/TACRES**2) STRT0650
STSEBD (ISPEC)=SQRT (STMVBD (ISPEC)/TACRES**2) STRT0660
IF (DFCB2 (ISPEC).EQ.0) GOTO 40 STRT0670
EPDFCB (ISPEC)=STVMCB (ISPEC)**2/DFCB2 (ISPEC) STRT0680
40 IF (DFBD2 (ISPEC).EQ.0) GOTO 50 STRT0690
EPDFBD (ISPEC)=STMVBD (ISPEC)**2/DFBD2 (ISPEC) STRT0700
50 CONTINUE STRT0710
RETURN STRT0720
END STRT0730

```



```

C*****
C PRINT REGRESSION ANALYSIS SUMMARY
C*****
C
  IF (REGANS.EQ.'YES') GOTO 90
  IPAGE=IPAGE+1
  WRITE(3,100) TITLE,IPAGE
  WRITE(3,20)
20 FORMAT('0',99('*')/' '*,97X,'*')/' '*,28X,'ANALYSIS OF THE HEIGHT',
1' DBH RELATIONSHIP',28X,'*')/' '*,97X,'*')/' '*,35X,'MODEL: HEI',
2'GHT = B0 + B1/DBH',34X,'*')/' '*,97X,'*')/' '*,99('*')/'0',99('-')
3/' ',15X,':',5X,'B0',4X,':',5X,'B1',4X,':',5X,'B',5X,': STANDAR',
4'D : AVERAGE : VOLUME : HEIGHT/' ' SPECIES : INTERC',
5'EPT : SLOPE : SQUARED : ERROR % : HEIGHT : TREES ',
6' : TREES/' ',99('-')/' ')
  IFLAG=0
  DO 50 ISPEC=1,32
    IF (TOTNTR(ISPEC).EQ.0) GOTO 50
    IF (NTR(ISPEC).LT.3.AND.NTR(ISPEC).LT.TOTNTR(ISPEC)) IFLAG=1
    IF (NTR(ISPEC).GE.3) WRITE(3,30) (SPETIT(ISPEC,J),J=1,3)
    1 ,REGINT(ISPEC),REGCOF(ISPEC),RSQR(ISPEC),SEREG(ISPEC)
    2 MEANY(ISPEC),TOTNTR(ISPEC),NTR(ISPEC)
30 FORMAT(' ',3(A5),2(':',F9.3,2X),3(':',F8.1,3X),2(':',I8,3X))
  IF (NTR(ISPEC).LT.3.AND.NTR(ISPEC).EQ.TOTNTR(ISPEC))
    1 WRITE(3,60) (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC)
    2 MEANY(ISPEC),TOTNTR(ISPEC),NTR(ISPEC)
  IF (NTR(ISPEC).LT.3.AND.NTR(ISPEC).LT.TOTNTR(ISPEC))
    1 WRITE(3,40) (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC)
    2 MEANY(ISPEC),TOTNTR(ISPEC),NTR(ISPEC)
40 FORMAT(' ',3A5,':',10X,'*** WARNING ***',10X,
  1 2(':',F8.1,3X),2(':',I8,3X))
50 CONTINUE
  WRITE(3,250)
  DO 70 ISPEC=33,35
    WRITE(3,60) (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC),MEANY(ISPEC)
    1 ,TOTNTR(ISPEC),NTR(ISPEC)
60 FORMAT(' ',3A5,':',35X,2(':',F8.1,3X),2(':',I8,3X))
70 IF (ISPEC.EQ.34.OR.ISPEC.EQ.35) WRITE(3,250)
  IF (IFLAG.EQ.1) WRITE(3,80)
80 FORHAT('0')/'0*** WARNING *** INSUFFICIENT NUMBER OF HEIGHT TR',
  1'EES MEASURED FOR THIS SPECIES!')
C
C *****
C OUTPUT STAND AND STOCK TABLES
C *****
C
90 DO 210 ISPEC=1,35
  IF (TRETOT (ISPEC).EQ.0.0) GOTO 210
  IPAGE=IPAGE+1
  WRITE(3,100) TITLE,IPAGE
100 FORMAT('1',14A5,26X,I3/'0')
C
C THE FOLLOWING SECTION CONTROLS THE OUTPUT OF THE SPECIES FORM CLASS
C PRINTED IN THE STAND TABLE HEADING. THE FORM CLASS IS NOT PRINTED
C UNDER THE FOLLOWING CONDITIONS:
C 1. STAND TABLES FOR SOFTWOOD,HARDWOOD, OR ALL SPECIES
C ( ISPEC >= 33 )
C 2. TREES MEASURED BY TOTAL HEIGHT ( TOPANS = "TOTAL" )
C 3. STAND TABLES FOR SOFTWOODS WHEN "MIXED" HEIGHTS USED
C ( TOPANS = "MIXED" AND ISPEC <= 11 )
C
  AFCTIT=' ' ; APCNUM=' '
  IF (ISPEC.GE.33) GOTO 120
  IF (TOPANS.EQ.'TOTAL') GOTO 120
  IF (TOPANS.EQ.'MIXED'.AND.ISPEC.LE.11) GOTO 120
  AFCTIT='FC = '
C ENCODE WRITES THE INTEGER VALUE OF FC INTO APCNUM AS ASCII CHARACTERS
  ENCODE(2,110,APCNUM) FC(ISPEC)
110 FORMAT(I2)
120 WRITE(3,130) (SPETIT(ISPEC,J),J=1,3),AFCTIT,APCNUM
130 FORMAT('0',99('*')/' '*,1,'*')/' '*,97X,'*')/' '*,
1,'*',39X,3(A5),35X,A5,2X,'*')/' '*,97X,'*')/' '*,
2,' ',99('*')/'0',99('-')/' ',10X,': BASAL AREA : ',
3' TREES : SAWLOG : SAWLOG : ',
4' PULPHWOOD/' ' DIAMETER : '6X,'PER',5X,':',6X,'PER',5X,':',
5' CUBIC FOOT VOLUME : BOARD FOOT VOLUME : CUBIC FOOT VOLUME/' '
6' ', ' CLASS',3X,':',5X,'ACRE',5X,
7' ':',5X,'ACRE',5X,3(':',5X,'PER ACRE',6X)/' ',99('-')/' ')

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DO 150 DBH=CLASIZ,40,CLASIZ                                OTP11560
IF (TREPAC(DBH,ISPEC).EQ.0.0) GOTO 150                    OTP11570
WRITE(3,140) DBH,BASPAC(DBH,ISPEC),TREPAC(DBH,ISPEC)     OTP11580
1 CBVLSM(DBH,ISPEC),BDVLSM(DBH,ISPEC),PLVLSM(DBH,ISPEC)  OTP11590
140 FORMAT(' ',4X,I2,4X,':',F10.1,4X,':',F10.1,4X,':',F10.1,  OTP11600
1 2(9X,':',F10.1))                                         OTP11610
150 CONTINUE                                               OTP11620
IF (PLTOT (ISPEC) .EQ.0) IERPUL=0                         OTP11630
IF (PLTOT (ISPEC) .NE.0) IERPUL=(SEPUL (ISPEC) *TVAL*100/PLTOT (ISPEC) ) +  OTP11640
1.5                                                         OTP11650
IF (CBTOT (ISPEC) .EQ.0) IERCUB=0                         OTP11660
IF (CBTOT (ISPEC) .NE.0) IERCUB=(SECUB (ISPEC) *TVAL*100/CBTOT (ISPEC) ) +  OTP11670
1.5                                                         OTP11680
IF (BDTOT (ISPEC) .EQ.0) IERBRD=0                         OTP11690
IF (BDTOT (ISPEC) .NE.0) IERBRD=(SEBRD (ISPEC) *TVAL*100/BDTOT (ISPEC) ) +  OTP11700
1.5                                                         OTP11710
WRITE(3,160) BASTOT (ISPEC) ,TRETOT (ISPEC) ,CBTOT (ISPEC) ,IERCUB,  OTP11720
1BDTOT (ISPEC) ,IERBRD,PLTOT (ISPEC) ,IERPUL              OTP11730
160 FORMAT('0',99(' ')/'0',3X,'TOTAL',2X,':',3X,F7.1,4X,':',3X,F7.1  OTP11740
1,4X,':',F10.1,'+',I3,'%',2(3X,':',F10.1,'+',I3,'%') /  OTP11750
2'+',52X,'_',2(19X,'_'/'0',99(' '))                      OTP11760
C CALCULATE AND OUTPUT MSD AND C.V.                       OTP11770
MSD=SQRT (BASTOT (ISPEC) /TRETOT (ISPEC) /.005454)       OTP11780
IBDCV=0 ; IPLCV=0                                         OTP11790
IF (BDTOT (ISPEC) .NE.0) IBDCV=SQRT (VARBRD (ISPEC) ) *100/BDTOT (ISPEC) +  OTP11800
1.5                                                         OTP11810
IF (PLTOT (ISPEC) .NE.0) IPLCV=SQRT (VARPUL (ISPEC) ) *100/PLTOT (ISPEC) +  OTP11820
1.5                                                         OTP11830
WRITE(3,170) MSD,IBDCV                                    OTP11840
170 FORMAT('0'/'0',5X,'MEAN STAND DIAMETER = ',F4.1      OTP11850
1,9X,'BOARD FOOT COEFFICIENT OF VARIATION = ',I4,'%')     OTP11860
C CALCULATE AND OUTPUT MERCHANTABLE MSD                   OTP11870
RBSTOT=BASTOT (ISPEC)                                     OTP11880
RTRTOT=TRETOT (ISPEC)                                     OTP11890
DO 180 DBH=CLASIZ,7,CLASIZ                                OTP11900
RBSTOT=RBSTOT-BASPAC (DBH,ISPEC)                          OTP11910
180 RTRTOT=RTRTOT-TREPAC (DBH,ISPEC)                       OTP11920
IF (RTRTOT.LT.0.01) RMSD=0                                OTP11930
IF (RTRTOT.GE.0.01) RMSD=SQRT (RBSTOT/RTRTOT/.005454)    OTP11940
WRITE(3,190) RMSD,IPLCV                                   OTP11950
190 FORMAT('0'/'0',5X,'MERCHANTABLE M.S.D. = ',F4.1      OTP11960
1,9X,'PULP-WOOD COEFFICIENT OF VARIATION = ',I4,'%')     OTP11970
C                                                           OTP11980
C CALCULATE AND OUTPUT (ESTIMATED) % CRUISE              OTP11990
IF (FRAME.EQ.'PLOT') PCTCRZ=100*(1.0-PINPOP)              OTP12000
IF (FRAME.EQ.'POINT') PCTCRZ=.5454*NPNTS*MSD*MSD/ACRES/BAF  OTP12010
WRITE(3,200) PCTCRZ                                       OTP12020
200 FORMAT('0'/'0',5X,'PERCENT CRUISE = ',F5.1,'%')      OTP12030
210 CONTINUE                                               OTP12040
C                                                           OTP12050
C *****                                                 OTP12060
C CALCULATE AND OUTPUT SPECIES COMPOSITION PERCENTAGES  OTP12070
C *****                                                 OTP12080
C                                                           OTP12090
IPAGE=IPAGE+1                                             OTP12100
WRITE(3,100) TITLE,IPAGE                                  OTP12110
WRITE(3,220)                                               OTP12120
220 FORMAT('0',99(' ')/' ',97X,'*' /  OTP12130
1,' ',30X,'SPECIES COMPOSITION BY PERCENT',37X,'*' /  OTP12140
2' ',97X,'*' / ' ',99(' ')/'0',99(' ')/  OTP12150
3' ',3(15X,':'),2(5X,'SANDLOG',6X,':'),4X,'PULPWOOD' /  OTP12160
4' ',3(15X,':'),3X,'CUBIC FOOT',4X,':',' BOARD FOOT'  OTP12170
5,4X,':',3X,'CUBIC FOOT' /  OTP12180
6' ',4X,'SPECIES',4X,':',' BASAL AREA ':',5X,'TREES  OTP12190
73(':',5X,'VOLUME',6X) / ' ',99(' ')/' ' )             OTP12200
IF (CBTOT (35) .EQ.0) CBOT (35) =-999                    OTP12210
IF (BDTOT (35) .EQ.0) BDOT (35) =-999                    OTP12220
IF (PLTOT (35) .EQ.0) PLTOT (35) =-999                   OTP12230
DO 240 ISPEC=1,34                                          OTP12240
IF (TRETOT (ISPEC) .EQ.0.0) GOTO 240                      OTP12250
BASCOM=BASTOT (ISPEC) *100/BASTOT (35)                    OTP12260
TRECOM=TRETOT (ISPEC) *100/TRETOT (35)                    OTP12270
CUBCOM=CBTOT (ISPEC) *100/CBTOT (35)                      OTP12280
BDCOM=BDTOT (ISPEC) *100/BDTOT (35)                       OTP12290
PULCOM=PLTOT (ISPEC) *100/PLTOT (35)                      OTP12300

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      WRITE(3,230) (SPETIT (ISPEC,J),J=1,3),BASCOM ,TRECUM,      OTP12310
1      CUBCOM,BDCOM,PULCOM      OTP12320
230  FORMAT(' ',3(A5),':',2(3X,F7.2,5X,':'),2(4X,F7.2,6X,':')      OTP12330
1      ',4X,F7.2)      OTP12340
240  IF (ISPEC.EQ.32) WRITE(3,250)      OTP12350
      WRITE(3,250)      OTP12360
250  FORMAT('0',99 ('-' )/' ')      OTP12370
      IF (CBTOT (35).EQ.-999)      CBTOT (35)=0      OTP12380
      IF (BDTOT (35).EQ.-999)      BDTOT (35)=0      OTP12390
      IF (PLTOT (35).EQ.-999)      PLTOT (35)=0      OTP12400
C      OTP12410
C *****      OTP12420
C OUTPUT VOLUME TOTALS FOR ALL SPECIES      OTP12430
C *****      OTP12440
C      OTP12450
      IPAGE=IPAGE+1      OTP12460
      WRITE(3,100) TITLE,IPAGE      OTP12470
      WRITE(3,260)      OTP12480
260  FORMAT('0',99 ('**')/' ',97X,'**/'      OTP12490
1' ',30X,'VOLUME TOTALS FOR ALL SPECIES',38X,'**/'      OTP12500
2' ',97X,'**/' ',99 ('**')/'0',99 ('-' )/'      OTP12510
3' ',15X,2 (': ',11X,'SAWLOG',11X),': ',10X,'PULPWOOD'/'      OTP12520
4' SPECIES      ':',6X,'CUBIC FOOT VOLUME',5X,': ',6X,'BOARD',      OTP12530
5' FOOT VOLUME',5X,': ',6X,'CUBIC FOOT VOLUME'/'      OTP12540
6' ',15X,2 (': ',10X,'PER ACRE',10X),': ',10X,'PER ACRE'/'      OTP12550
7' ',99 ('-' )/' ')      OTP12560
      DO 290 ISPEC=1,35      OTP12570
      IF (CBTOT (ISPEC).EQ.0.AND.PLTOT (ISPEC).EQ.0.AND.ISPEC.LT.33)      OTP12580
1      GOTO 280      OTP12590
      WRITE(3,270) (SPETIT (ISPEC,J),J=1,3),CBTOT (ISPEC),BDTOT (ISPEC),      OTP12600
1      PLTOT (ISPEC)      OTP12610
270  FORMAT(' ',3(A5),3 (': ',F17.1,11X))      OTP12620
280  IF (ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35) WRITE(3,250)      OTP12630
290  CONTINUE      OTP12640
C      OTP12650
C *****      OTP12660
C OUTPUT VOLUME TOTALS EXPANDED BY ACREAGE      OTP12670
C *****      OTP12680
C      OTP12690
      IPAGE=IPAGE+1      OTP12700
      WRITE(3,100) TITLE,IPAGE      OTP12710
      WRITE(3,300)      OTP12720
300  FORMAT('0',99 ('**')/' ',97X,'**/'      OTP12730
1' ',30X,'VOLUME TOTALS EXPANDED BY ACREAGE',34X,'**/'      OTP12740
2' ',97X,'**/' ',99 ('**')/'0',99 ('-' )/'      OTP12750
3' ',15X,2 (': ',11X,'SAWLOG',11X),': ',10X,'PULPWOOD'/'      OTP12760
4' SPECIES      ':',6X,'CUBIC FOOT VOLUME',5X,': ',6X,'BOARD',      OTP12770
5' FOOT VOLUME',5X,': ',6X,'CUBIC FOOT VOLUME'/'      OTP12780
6' ',99 ('-' )/' ')      OTP12790
      DO 330 ISPEC=1,35      OTP12800
      IF (CBTOT (ISPEC).EQ.0.AND.PLTOT (ISPEC).EQ.0.AND.ISPEC.LT.33)      OTP12810
1      GOTO 320      OTP12820
      TOTACB=CBTOT (ISPEC)*ACRES+.5      OTP12830
      TOTABD=BDTOT (ISPEC)*ACRES+.5      OTP12840
      TOTAPL=PLTOT (ISPEC)*ACRES+.5      OTP12850
      WRITE(3,310) (SPETIT (ISPEC,J),J=1,3),TOTACB,TOTABD,TOTAPL      OTP12860
310  FORMAT(' ',3(A5),3 (': ',I17,11X))      OTP12870
320  IF (ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35) WRITE(3,250)      OTP12880
330  CONTINUE      OTP12890
      RETURN      OTP12900
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```

C
C ***** OTP12910
C ***** OTP12920
C ***** OTP12930
C OUTPUT TABLES FOR STRATIFIED TOTAL OTP12940
C ***** OTP12950
C ***** OTP12960
C ***** OTP12970
C ENTRY OUTP2 OTP12980
  WRITE(5,340) OTP12990
340 FORMAT('OWHAT DO YOU WANT TO TITLE THE COMBINED STRATA OUTPUT?') OTP13000
  READ(5,350) TITLE OTP13010
350 FORMAT(14A5) OTP13020
  IPAGE=IPAGE+1 OTP13030
  WRITE(3,100) TITLE,IPAGE OTP13040
C PRINT HEADING ON OUTPUT FILE OTP13050
  OFRAME=FRAME OTP13060
  IF (FRAME.EQ.'PLOT') OFRAME=' PLOT' OTP13070
  WRITE(3,360) IDATE,CLASIZ,ISTRA,TACRES,OFRAME,TOTPTS,ALPHA OTP13080
360 FORMAT(/' INVENT VER. 3 11/1/78 I.N.E.R. U.N.H.'// OTP13090
  1'ODATE OF RUN: ',2A5// OTP13100
  2'ODIAMETER CLASS SIZE =' ,I3,21X,'NUMBER OF STRATA SAMPLED =' OTP13110
  3,I3/'OTOTAL ACREAGE SAMPLED =' ,F9.1,13X,'TOTAL ',A5 OTP13120
  4,'S SAMPLED =' ,I5/'OCONFIDENCE LEVEL = ',F3.2) OTP13130
C ***** OTP13140
C ***** OTP13150
C ***** OTP13160
C ***** OTP13170
C ***** OTP13180
C ***** OTP13190
C ***** OTP13200
C ***** OTP13210
C ***** OTP13220
C ***** OTP13230
C ***** OTP13240
C ***** OTP13250
C ***** OTP13260
C ***** OTP13270
C ***** OTP13280
C ***** OTP13290
C ***** OTP13300
C ***** OTP13310
C ***** OTP13320
C ***** OTP13330
C ***** OTP13340
C ***** OTP13350
C ***** OTP13360
C ***** OTP13370
C ***** OTP13380
C ***** OTP13390
C ***** OTP13400
C ***** OTP13410
C ***** OTP13420
C ***** OTP13430
C ***** OTP13440
C ***** OTP13450
C ***** OTP13460
C ***** OTP13470
C ***** OTP13480
C ***** OTP13490
C ***** OTP13500
C ***** OTP13510
C ***** OTP13520
C ***** OTP13530
C ***** OTP13540
C ***** OTP13550
C ***** OTP13560
C ***** OTP13570
C ***** OTP13580
C ***** OTP13590
C ***** OTP13600
C ***** OTP13610
C ***** OTP13620
C ***** OTP13630
C ***** OTP13640
C ***** OTP13650
C ***** OTP13660
C ***** OTP13670
C ***** OTP13680
C ***** OTP13690
C ***** OTP13700
C ***** OTP13710

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```
C
C*****
C OUTPUT ALL SPECIES VOLUME TABLE
C*****
C
  IPAGE=IPAGE + 1
  WRITE(3,100) TITLE,IPAGE
  WRITE(3,460)
460 FORMAT('0',99('*')/' ',97X,'*'/
1' ',30X,'VOLUME TOTALS FOR ALL SPECIES',38X,'*'/
2' ',97X,'*'/ ' ',99('*')/'0',99('-')/
3' ',15X,2(':',11X,'SAWLOG',11X),':',10X,'PULPWOOD'/
4' ',SPECIES ':',6X,'CUBIC FOOT VOLUME',5X,':',6X,'BOARD ',
5'FOOT VOLUME',5X,':',6X,'CUBIC FOOT VOLUME'/
6' ',99('-')/' ')
  DO 480 ISPEC=1,35
    IF(CBTST(ISPEC).EQ.0.AND.PLTST(ISPEC).EQ.0.AND.ISPEC.LT.33)
      1      GOTO 470
      ICBTST=CBTST(ISPEC)+.5 ; IBDTST=BDTST(ISPEC)+.5
      IPLTST=PLTST(ISPEC)+.5
      WRITE(3,310) (SPETIT(ISPEC,J),J=1,3),ICBTST,IBDTST,IPLTST
470   IF (ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35) WRITE(3,250)
480 CONTINUE
  RETURN
  END
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OTP13720  
OTP13730  
OTP13740  
OTP13750  
OTP13760  
OTP13770  
OTP13780  
OTP13790  
OTP13800  
OTP13810  
OTP13820  
OTP13830  
OTP13840  
OTP13850  
OTP13860  
OTP13870  
OTP13880  
OTP13890  
OTP13900  
OTP13910  
OTP13920  
OTP13930  
OTP13940  
OTP13950  
OTP13960

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C                               MDST0010
C   SUBROUTINE MDSTI (Q,F,X)     MDST0020
C                               MDST0030
C ***** MDST0040
C                               MDST0050
C   THIS SUBPROGRAM IS COMPOSED OF TWO SUBROUTINES ADAPTED FROM THE MDST0060
C   INTERNATIONAL MATHEMATICAL AND STATISTICAL LIBRARIES, INC. (IMSL) MDST0070
C   MDSRI - INVERSE STUDENT'S T DISTRIBUTION MDST0080
C   MDNRIS - INVERSE NORMAL PROBABILITY DISTRIBUTION FUNCTION MDST0090
C   BOTH SUBROUTINES HAVE BEEN EDITED REMOVING CAPABILITIES NOT NEEDED MDST0100
C   IN THIS APPLICATION. THE REMAINING CODE IS REPRODUCED HERE IN MDST0110
C   ACCORDANCE WITH THE IMSL POLICY ON RESEARCH WOPK AS STATED ON MDST0120
C   PAGE INTRO-22 OF THE JULY, 1977 LIBRARY MANUAL. MDST0130
C ***** MDST0140
C                               MDST0150
C                               MDST0160
C                               EXACT INTEGRAL FOR 2 D.F. MDST0170
C   IF (ABS(F-2.0) .GT. .000001) GO TO 10 MDST0180
C   X = SQRT(2.0/(Q*(2.0-Q))-2.0) MDST0190
C   GO TO 50 MDST0200
10 HPI = 1.570796 MDST0210
C                               EXACT INTEGRAL FOR 1 D.F. MDST0220
C   IF (ABS(F-1.0) .GT. .000001) GO TO 20 MDST0230
C   A = Q*HPI MDST0240
C   X = COS(A)/SIN(A) MDST0250
C   GO TO 50 MDST0260
C                               EXPANSION FOR N GREATER THAN 2 MDST0270
20 A = 1.0/(F-0.5) MDST0280
C   B = 48.0/(A*A) MDST0290
C   C = ((20/00.*A/B-98.) *A-16.) *A+96.36 MDST0300
C   D = ((94.5/(B+C)-3.0) /B+1.0) *SQRT(A*HPI) *F MDST0310
C   XX = D*Q MDST0320
C   Y = XX**(2.0/F) MDST0330
C   IF (Y .GT. A+.05) GO TO 40 MDST0340
C   Y = ((1.0/(((F+6.0)/(F*Y)-0.089*D-0.822) *(F+2.0)*3.0) + MDST0350
1   0.5/(F+4.0) ) *Y-1.0) * (F+1.0) / (F+2.0) +1.0/Y MDST0360
30 X = SQRT(F*Y) MDST0370
C   GO TO 50 MDST0380
C                               ASYMPTOTIC INVERSE EXPANSION ABOUT MDST0390
C                               NORMAL MDST0400
C                               MDST0410
40 X = .5 * Q MDST0410
C   CALL MDNRIS(X,XX) MDST0420
C   Y = XX * XX MDST0430
C   IF (F .LT. 5.) C = C+0.3*(F-4.5) *(XX+0.6) MDST0440
C   Y = (((.05*D*XX-5.0) *XX-7.0) *XX-2.0) *XX+B+C MDST0450
C   Y = (((((0.4*Y+6.3) *Y+36.) *Y+94.5) /C-Y-3.0) /B+1.0) *XX MDST0460
C   Y = A*Y*Y MDST0470
C   D = Y MDST0480
C   Y = .05*Y*Y+Y MDST0490
C   IF (Y .GT. .002) Y = EXP(D) - 1.0 MDST0500
C   GO TO 30 MDST0510
50 RETURN MDST0520
C   END MDST0530

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SUBROUTINE MDNRIS(P,Y)
DATA          SQRT2/1.4142136/
DATA          A1,A2,A3/-.57517029,-1.8965133,-.054962605/
DATA          B0,B1,B2,B3/-.11377303,-3.2934740,-2.3749959,
1            -1.1875145/
DATA          C0,C1,C2,C3/-.11466659,-.13147744,-.23682010,
1            -.050739749/
DATA          D0,D1,D2/-44.279769,21.985462,-7.5861027/
DATA          E0,E1,E2,E3/-.0566842208,.39370209,-.31665010,
1            .062089629/
DATA          F0,F1,F2/-6.2667859,4.6662627,-2.9628832/
DATA          G0,G1,G2,G3/-.00018511591,-.0020281520,
1            -.14983844,.010786386/
DATA          H0,H1,H2/.099529751,.52117329,-.068883009/
GO TO 40
10 IP (X.LT. .15) GO TO 30
   IP (X.LT.1.85) GO TO 20
   SIGMA = -1.
   A = 2.-X
   B = X-1.
   GO TO 50
20 Z = 1.-X
   SIGMA = SIGN(1.,Z)
   Z = ABS(Z)
   GO TO 80
30 SIGMA = 1.
   A = X
   B = 1.-X
   GO TO 50
C
C                               INVERSE GAUSSIAN ENTRY
40 INT = 3
   X = 2.*P
   GO TO 10
C
C                               REDUCED ARGUMENT IS IN (.85,1.),
C                               OBTAIN THE TRANSFORMED VARIABLE
50 W = SQRT(-ALOG(A+A*B))
   IF (W.LT.2.5) GO TO 70
   IF (W.LT.4.) GO TO 60
C
C                               W GREATER THAN 4., APPROX. F BY A
C                               RATIONAL FUNCTION IN 1./W
   WI = 1./W
   SN = ((G3*WI+G2)*WI+G1)*WI
   SD = ((WI+H2)*WI+H1)*WI+H0
   F = W + W*(G0+SN/SD)
   GO TO 90
C
C                               W BETWEEN 2.5 AND 4., APPROX. F
C                               BY A RATIONAL FUNCTION IN W
60 SN = ((E3*W+E2)*W+E1)*W
   SD = ((W+F2)*W+F1)*W+P0
   F = W + W*(E0+SN/SD)
   GO TO 90
C
C                               W BETWEEN 1.13222 AND 2.5, APPROX.
C                               F BY A RATIONAL FUNCTION IN W
70 SN = ((C3*W+C2)*W+C1)*W
   SD = ((W+D2)*W+D1)*W+D0
   F = W + W*(C0+SN/SD)
   GO TO 90
C
C                               Z BETWEEN 0. AND .85, APPROX. F
C                               BY A RATIONAL FUNCTION IN Z
80 Z2 = Z*Z
   F = Z+Z*(B0+A1*Z2/(B1+Z2+A2/(B2+Z2+A3/(B3+Z2))))
C                               FORM THE SOLUTION BY MULT. F BY
C                               THE PROPER SIGN
90 Y = SIGMA*F
   IF (INT.NE.3) GO TO 100
   Y = -Y*SQRT2
100 RETURN
END
MDNR0010
MDNR0020
MDNR0030
MDNR0040
MDNR0050
MDNR0060
MDNR0070
MDNR0080
MDNR0090
MDNR0100
MDNR0110
MDNR0120
MDNR0130
MDNR0140
MDNR0150
MDNR0160
MDNR0170
MDNR0180
MDNR0190
MDNR0200
MDNR0210
MDNR0220
MDNR0230
MDNR0240
MDNR0250
MDNR0260
MDNR0270
MDNR0280
MDNR0290
MDNR0300
MDNR0310
MDNR0320
MDNR0330
MDNR0340
MDNR0350
MDNR0360
MDNR0370
MDNR0380
MDNR0390
MDNR0400
MDNR0410
MDNR0420
MDNR0430
MDNR0440
MDNR0450
MDNR0460
MDNR0470
MDNR0480
MDNR0490
MDNR0500
MDNR0510
MDNR0520
MDNR0530
MDNR0540
MDNR0550
MDNR0560
MDNR0570
MDNR0580
MDNR0590
MDNR0600
MDNR0610
MDNR0620
MDNR0630
MDNR0640
MDNR0650
MDNR0660
MDNR0670
MDNR0680

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